i-ENGINEERING

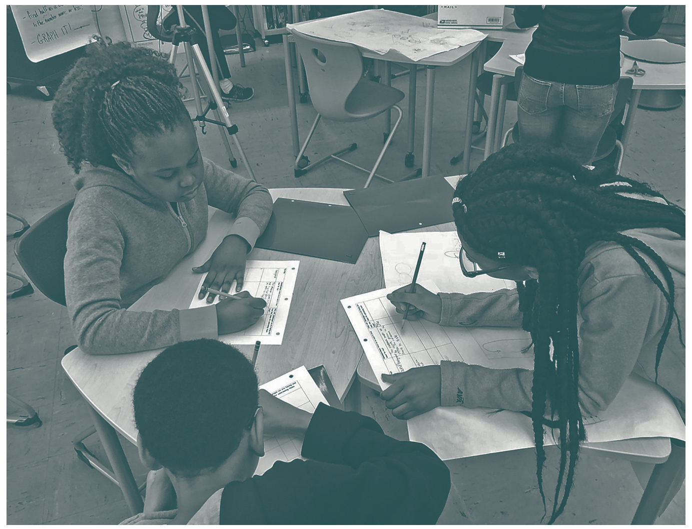
ENGINEERING for SUSTAINABLE COMMUNITIES

CURRICULUM

UNIVERSITY OF MICHIGAN

UNC GREENSBORO

KEY TERMS



LESSON 1

Engineering Using science, math, and creativity to design solutions to solve problems.

Sustainable community A group of people that cares about each other and the environment and works together to make their community a better place

LESSON 2

Circuit The path that electrons flow, that begins and ends in the same place.

Current How much electricity is flowing through the circuit. A higher current means more electricity is flowing. Current is measured in amperes. The symbol for amperes is *A*.

Simple circuit A circuit that only has a single load, such as one light bulb or one noisemaker.

Series electric circuit The current passes through each load in a single branch in consecutive order

Parallel electric circuit The current divides as it flows through separate branches and then is combined again

Power source The energy source that powers the circuit

Load The electricity energy is transferred to in a circuit

Pathway The way electricity flows through a circuit

Switch An object that opens and closes a circuit to complete it

Voltage How hard electricity is being "pushed" through a circuit. A higher voltage means the electricity is being pushed harder. Voltage is measured in volts. The symbol for volts is *V*.

Kinetic energy Energy of motion

Potential energy Energy that is stored

LESSON 3

Trade-offs One important aspect of what engineers do every day is to analyze and improve efficiency. By making changes to technology and human processes, engineers are always trying to think of new ways to save us time, energy, materials and costs. Engineers also look for ways to save people time in their daily lives by making "trade-offs." A trade-off occurs when we sacrifice one thing to gain something else that we value more. Trade-off decisions are made for social, environmental and sometimes economic benefits

Energy The ability to do work. There are many forms of energy, such as electrical, chemical, human, and solar.

Green (renewable) energy Energy that is collected by renewable resources and naturally replenished on a human time scale. Green energy is electricity that is created from renewable resources.

The law of conservation of energy Energy is never lost in a system, it just changes its form. For example, electricity is a form of energy. It is changed from electric energy to both heat and light energy when a desk lamp is lit.

Hand crank In electricity, a generator is a device that converts mechanical energy (the sum of potential energy and kinetic energy and is the energy associated with the motion and position of an object) into electrical energy for use in a circuit.

Solar panel Solar energy is radiant energy emitted by the sun or power obtained by harnessing the energy of the sun's rays. The panels store this energy until it is transformed into electricity.

Piezoelectric pads Vibrational energy is converted into electricity with these. Vibrational energy is a type of mechanical energy

LESSON 4

Sustainability Caring about making positive environmental impacts while creating long term solutions for the community.

LESSON 5

Technical aspects A set of requirements that a product must meet, such as size, workload, number of parts, power requirements, etc.

Social aspects Information from the community about the desired specifications of the product, such as easy to use, helpful to people, does not cost a lot, makes the community happier or healthier.

LESSON 7

Design optimization Involves making trade-offs among competing criteria to meet your desired needs (technical and social).

CONTENTS

INTRO TO I-ENGINEERING

Welcome to i-Engineering for Sustainable Communities!

i-Engineering is a justice-oriented approach to teaching engineering in the middle grades and is aligned with the Next Generation Science Standards. This curriculum provides middle school classrooms with two connected engineering design units focused on engineering for sustainable communities:

- Designing and iterating on electric art for loved ones
- Creating sustainable, green-energy powered engineering design solutions for their classroom.

These two design challenges are grounded in the core ideas of energy transformations, sources and systems, and sustainability, alongside engineering practices.

Why take an EfSC approach?

Engineering for sustainable communities is an approach to engineering that values learning and doing engineering with and for the community in support of building a healthier, happier and more just world.

The Engineering for Sustainable Communities (EfSC) approach supports students in engineering more healthy, happy and just communities in their classrooms, schools and neighborhoods. EFSC explicitly connects students and teachers to communities. Students learn to identify and balance community needs and rights with the technical problem solving of engineering.

A sustainable communities approach supports teachers and students in working with each other and their communities to draw upon a diverse and distributed set of expertise to understand and address challenges at both the local and systemic level. It requires students and teachers to ask, *Whose knowledge counts? Who takes action?*. We want students to be able to say, "I can begin to solve this problem collaboratively right here in my community, right now using what I know" rather than waiting to only use their STEM expertise in long-term future career goals or deferring to experts outside of their communities who are positioned as experts. This is important to challenge both the ways that schooling practices have perpetuated epistemic violence on youth marginalized by dominant science education as well as material forms of broader societal oppression.

How does I-Engineering support students in learning the practices of engineering?

The EFSC approach is undergirded by the engineering practices of: **defining problems** and **designing solutions.** As students engage in these practices they learn how to iterate on their designs as they learn to bound their problem spaces and optimize their designs. These practices also support students in making sense of problems and solutions in careful, balanced ways. An EFSC approach also supports students in developing their engineering identities by supporting them in having opportunities to use what they know to make a difference in their communities, and to be recognized for it.

Each design challenge is guided by a driving question and moves students through three phases:

PHASE 1

Defining the Problem

This phase focuses on learning how to define an engineering problem, which requires thoughtful integration of engineering and community expertise. To support youth in more precisely understanding a design task's boundaries, including its criteria and constraints from this integrated vantage point, we designed lessons to support students in seeking out, analyzing, and integrating both scientific and community knowledge to specify, expand or limit movement towards possible solutions. This phase introduces students to the principles of EFSC.

PHASE 2

Designing Solutions

Students are supported in systematically fleshing out their design solutions. Integrated are lessons/activities focused on community survey for generating and analyzing multiple perspectives and deepening knowledge of disciplinary core ideas to enable more robust solutions. The process focuses on the ongoing refining of design constraints, evaluating possible solutions towards optimization, and multiple cycles of designing/conducting tests towards optimizing solutions, gathering/ analyzing data from multiple perspectives including peers, school personnel and families, and engaging in dialog on complicated conflicts in perspective and design trade-offs. A significant aspect of this design phase includes presenting design solutions, with rationales and data, to outside experts, including engineers, science educators and community members. Students are supported in breaking down the process through a sequential series of physical representations.

PHASE 3

Prototyping & Optimizing Solutions

In this phase, youth build, test and refine working prototypes as they communicate on-going findings with school and community stakeholders in order to critically think through maximizing trade-offs. The lessons support youth in making visible the iterative nature of design work. Students are scaffolded in functionally decomposing, then organizing and trying out different computations informed by different perspectives/ feedback obtained.

#	Lesson	Key Focus	Integration of Community Perspectives
1	Introduction	Big Ideas in Engineering for Sustainable Communities **Lesson 1:** Introduction	Examining & discussing how youth their age use community ethnography as a part of engineering design
2–3	Iterative Design Cycle 1	Using iterative design cycles to make electric art cards for family/friends, powered with green energy sources **Lesson 2:** Designing Electric Art **Lesson 3:** Sustainable Electric Art	Generating Community Narratives
4–9	Iterative Design Cycle 2	Defining problems and designing solutions through community ethnography **Lesson 4:** Engineering Design Cycle **Lesson 5:** Design Challenge **Lesson 6:** Initial Design **Lesson 7:** Design Optimization with Community Feedback **Lesson 8:** Prototyping Designs **Lesson 9:** Refining Your Prototype	Using community ethnography as a part of engineering design Surveys & observations of peers & community members Dialogs with community on project ideas/design Observation
10	Community Sharing	**Lesson 10:** Sharing Engineering Designs	Community Narratives

INTRO TO I-ENGINEERING

Table 1: Practices in Engineering for Sustainable Communities

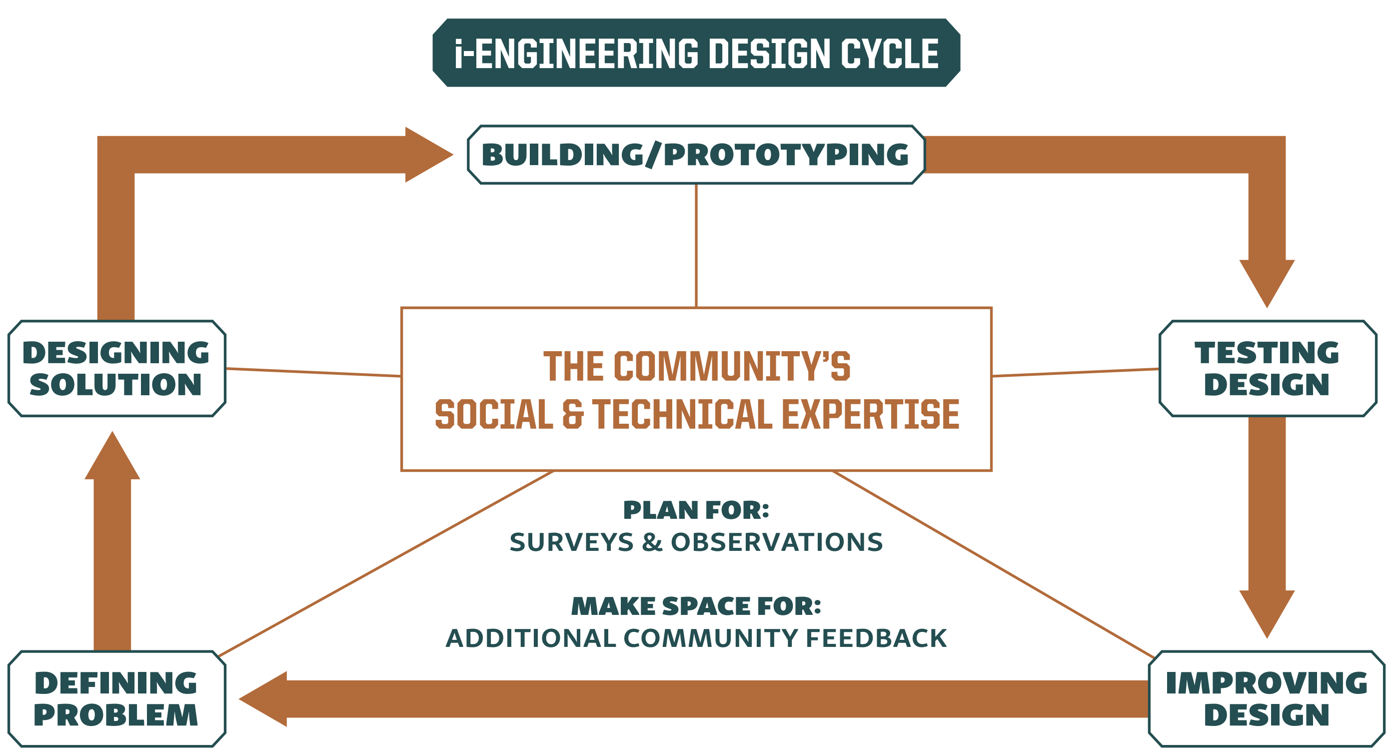
	Technical	Social	Interactions
DEFINING PROBLEMS	What problems can technology solve? What do I need to know about the technology to solve the problem?	How can I identify, seek out and incorporate multiple perspectives from relevant stakeholders? How can I translate my technical thinking into questions, ideas and concerns for outsiders?	SETTING CRITERIA What perspectives matter and why? How do different perspectives constrain problems differently and why does this matter?
DESIGNING SOLUTIONS	How do I decide on a design that best meets the criteria and constraints? What do I build and how do I test it? What do I need to know to optimize my design?	What perspectives should my design address and how do I test my design against these perspectives? How do I communicate ongoing design decisions to others who may not have the same knowledge as me?	OPTIMIZING Which criteria are most important? How do I balance conflicting factors? How do I maximize trade-offs?

Technical and Social Dimensions

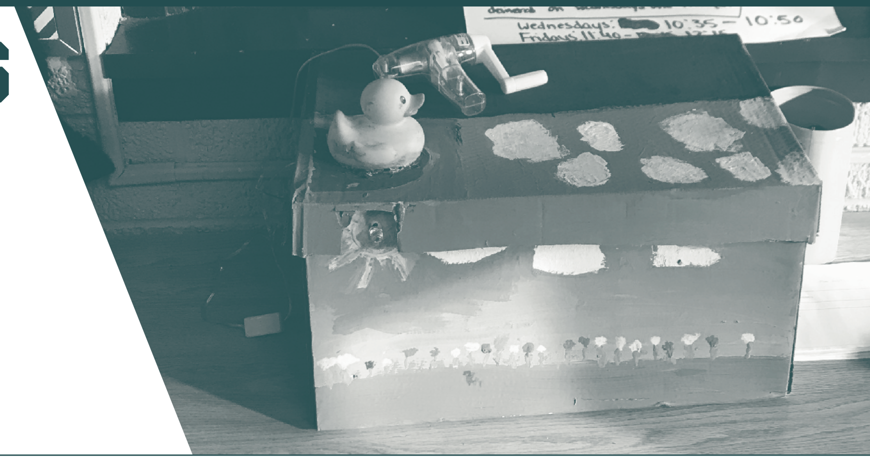
Teaching engineering for sustainable communities requires teachers and students to consider the technical challenge of design as well as how problems and solutions are defined, adapted, and optimized in response to community needs (See **Table 1**). This necessitates an approach to engineering that moves beyond traditional content and practice to incorporate the social dimensions of problems and solutions. To operationalize this in our EfSC framework, we invited teachers and students to pay attention to both technical and social specifications, and the interactions between them.

The EfSC Design Cycle

The core principles for Engineering for Sustainable Communities are also present in the engineering design cycle use for i-Engineering. The elements related to communities' perspective and sustainability are the new aspects that make our design cycle distinctive from other design cycle. The EfSC Design Cycle (see below) also serves as guidelines for the youth engineers while they engage in the design process.



CORE CONCEPTS & PRACTICES



In this unit, there are important concepts and ideas that teachers and students might find helpful to navigate through the teaching/learning process of Engineering for Sustainable Communities (EfSC). In each lesson, teachers and students will have the opportunity to engage with the concepts and/or ideas through specific activities designed to scaffold the students' engineering final design. Below, we present each of these ideas and concepts by focusing in sustainable ways of energy production, including:

- Principles for teaching EfSC
- Types of circuit and how energy flows through them
- Renewable and non-renewable sources of energy

EfSC Principles

For the engineering challenge of this unit, students learn to see the EfSC principles as the guiding design principles. You may also read the article *"Teaching Engineering for Sustainable Communities: An Equity-Oriented Approach for Teachers"* available in the teacher materials if you want further information.

Below, we highlight core design principles for teaching engineering for sustainable communities that are integrated across the unit and are intended to support teachers in teaching engineering practices from this perspective.

- Communities' perspectives matter in design
- Balances technical dimensions with community needs
- Helps others now and in the future
- Minimizes negative environmental impacts

Make sure to keep these principles in mind as you support students in systematically refining design constraints and evaluating possible solutions towards optimization in the unit.

Circuits & Energy Transformations

In this unit, students create circuits as a way to investigate power transformations. Circuits are closed loops through which electricity travels. Every circuit requires a power source. Electrons travel from areas of high electric potential to areas of low electron potential along a conductive path. The lesson where we start addressing this concept is in lesson one. In the lesson the materials that will be used to create circuits are copper

tape, LED lights bulbs, and coin batteries. The conductive path will be copper tape in this lesson, the load will be the light bulbs, and the power source will be small coin batteries.

There are two main types of circuits used in this unit: series circuit, and parallel circuit (See **Figure 1.2**). The electrons flow through a single path through multiple loads in series circuits. In a parallel circuit, the electrons flow through different paths, and only pass through one load per path, such as a light bulb before returning to the battery. As electrons pass through light bulbs and/or other loads like sound makers, they encounter resistance. The more resistance electrons encounter requires more energy. Therefore, series circuits with three light bulbs require more power compared to a three light bulb parallel circuit.

Series Connection Parallel Connection

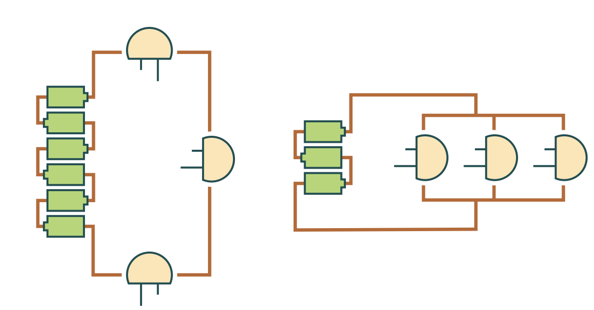


Figure 1.2 Two types of circuits

CORE CONCEPTS & PRACTICES

Renewable and Non-Renewable Energy Sources
Energy is the ability to do work. It can be found in many forms. In this unit, we focus primarily on electrical energy and its transformation to light and sound. However, students also learn that electrical energy is generated by transformations of other energy sources, including chemical, solar, and human energy (mechanical). It's important for students distinguish between renewable and non-renewable resources. Renewable energy resources are energy sources that do not run out ex. wind, and sun. Non-renewable energy sources are energy sources that cannot be replenished on a human timescale (e.g. coal, oil). In particular, they will first focus on batteries to connect with their circuit artwork. Then they will discuss coal in connection to the largest source of electricity production in Michigan and North Carolina. By doing this, students will be able to build off their previous work, and also will be able to use this knowledge to think more about their community energy production and practices. Then students will explore the law of conservation of energy and energy transformations.

In **Lesson 3**, students learn about the affordances of different sources of electricity, from both a technical and a social standpoint. They discovered it is hard physical work to produce all of their own electricity, but they also learn that simpler methods like coal produce environmental waste. They learn to figure out what trade-offs they want to make—a critical dimension to the engineering practice of designing solutions. They learn that each design decision carries with it consequences.

Optimizing Engineering Design
Multiple solutions to an engineering design problem are always possible because there is more than one way to meet the criteria and satisfy the constraints. But the aim of engineering is not simply to design a solution to a problem but to design the best solution. Determining what constitutes "best", however, requires value judgments, given that one person's view of the optimal solution may differ from another's. Optimization often requires making trade-offs among competing criteria. For example, as one criterion (such as lighter weight) is enhanced, another (such as unit cost) might be sacrificed (i.e., cost may be increased due to the higher cost of lightweight materials). In effect, one criterion is devalued or traded off for another that is deemed more important. When multiple possible design options are under consideration, with each optimized for different criteria, engineers may use a trade-off matrix to compare the overall advantages and disadvantages of the different proposed solutions.

Prototyping Designs
Students will prototype their design beginning in **Lesson 7** and refine it throughout the rest of the unit. A prototype is a representation of the final product. Prototypes vary in how realistic they are. For examples, engineers build small prototypes of skyscrapers that can fit in an office while others create working appliance prototypes to test them before designing full-scale manufacturing processes. They should make them as functional as possible. This will vary from group to group. If students' designs stayed within the constraints of using only hand-cranks, solar panels, or piezoelectric pads to light up something or make noises, students should be able to work in groups independently.

ENGINEERING for SUSTAINABLE COMMUNITIES \\ CURRICULUM

I-ENGINEERING & NEXT GENERATION SCIENCE STANDARDS ALIGNMNET

Conservation of Energy and Energy Transfer
What is this disciplinary core idea? The NGSS supports students in iteratively deepening their understanding of the conservation and transfer of energy. Energy is never destroyed or created within in a system though it can be transferred within the system.

How does i-Engineering support developing this disciplinary core idea? Using electric systems as one type of system, i-Engineering supports students in understanding how energy transfers occur and understanding energy conservation within that system. As they design complex working circuits, students must design systems that allow for energy transfers through electrical currents. They learn this content as they are enacting the practices of defining problems and designing solutions.

Engineering Practices
The Next Generation Science Standards have placed a new emphasis on students enacting science and engineering practices. i-Engineering is designed to support teachers and students in engaging in these practices. i-Engineering focuses specifically on the engineering practices of defining problems and designing solutions.

Defining Problems
What is this practice? Students ask questions and gather information to determine specific challenges that need to be addressed and possibilities and constraints of their engineering solution. In this process, they gather and analyze information to properly define the dimensions of a problem. Students enacting this practice in i-Engineering focus on both the technical and social dimensions of the challenges they are addressing.

How does i-Engineering support enacting this practice? This curriculum is designed around two design units. Each unit is based on a design challenge that require students to integrate knowledge energy systems with the engineering practice define a problem: designing an electric art card for a friend and creating an engineering design to make their classroom community more sustainable. Students utilize multiple community ethnography tools, such as surveys, observations and interviews, to gather information about the problems they are seeking to define. Then, they are supported in analyzing the data they generated. This ongoing process continues throughout the i-Engineering unit(s).

Designing Solutions
What is this practice? Students design solutions that address the multi-faceted dimensions of the problems they defined. While students engage in designing solutions, they determine and balance different constraints for their engineering design. i-Engineering supports students in considering both the technical and social constraints and opportunities of their engineering design solutions.

How does i-Engineering support enacting this practice? After students define the problem they address, they create a sketch-up that highlights the technical and social specifications of their design. They share this sketch-up and seek feedback from community experts. Using this feedback, they optimize their designs and prototype it. Then they design and run both technical and social tests to further optimize their engineering design solution.

On the next page, our standards Cross-Walk Table shows the specific performance expectations i-Engineering addresses.

I-ENGINEERING & NEXT GENERATION SCIENCE STANDARDS ALIGNMENT

Lesson	Scientific Practices	Teaching Tools/Student Activities	Identity Development	NGSS Standards					
				MS-ESS3-3	MS-ETS1-1	MS-ETS1-2	MS-ETS1-3	MS-ETS1-4	MS-PS3-5
Lesson 1: Introduction									
I. Design Principles for EfSC	Asking questions, defining problems	EfSC principles	Recognition; Agency	✔	✔				
	Constructing explanations, designing solutions	Occupied video	Recognition	✔	✔				
Lesson 2: Designing Electric Art									
I. Introduce Design Challenge	Asking questions, defining problems	Electric art challenge introduction	Recognition		✔		✔		✔
II. Prototype 1	Developing and using models	Electric art templates	Recognition		✔		✔		✔
III. Prototype 2	Developing and using models; planning investigations	Circuit drawing worksheets	Recognition		✔	✔	✔	✔	✔
V. Drawing & Explaining Electric Art Cards	Engaging in argument from evidence; obtaining		Recognition			✔			✔
Lesson 3: Sustainable Electric Art									
I. What is Energy?	Asking questions, defining problems	Apple demonstration	Recognition						✔
	Planning investigations	Energy transformation demo of rubbing hands							✔
II. How do We Produce Energy?	Engaging in argument from evidence	Energy transfer and use video	Recognition	✔					
IV. Comparing Trade-Offs of Different Energy Sources	Constructing explanations, designing solutions	Renewable energy stations and worksheets	Recognition	✔	✔				✔
Lesson 4: Engineering Design Cycle									
I. Video Analysis	Analyzing and interpreting data	Youth engineering design video	Recognition	✔	✔				
II. Linking EfSC with the Engineering Cycle	Engaging in argument from evidence	EfSC design cycle	Recognition	✔	✔	✔			
Lesson 5: Design Challenge									
I. Introduce Engineering Design Challenge	Asking questions, defining problems	Discussion	Recognition	✔		✔	✔		
II-III. Admnistering Surveys	Asking questions, defining problems	Using community ethnography to develop a survey	Recognition		✔				
V. Data Analysis	Analyzing and interpreting data	Analyzing community ethnography survey data	Recognition	✔	✔	✔			
Lesson 6: Initial Design									
I. Modeling Sketch-ups	Developing and using models	Modeling how to make a sketch-up	Recognition	✔	✔			✔	
III. Initial Design Sketch-ups		Initial design sketch-up		✔	✔			✔	
Lesson 7: Design Optimization with Community Feedback									
II. Create Interview Protocol	Asking questions, defining problems	Creating interview with technical and social questions	Recognition	✔	✔				
III. Optimize Design	Analyzing and interpreting data	Analyzing community ethnography data	Recognition	✔	✔				
	Asking questions, defining problems	Incorporating interview feedback into sketch-ups		✔	✔	✔			
IV. Class Presentations and Feedback	Engaging in argument from evidence	Presenting sketch-up and changes based on feedback	Recognition		✔				
Lesson 8: Prototyping Designs									
II. Create Prototype Plan	Constructing explanations, designing solutions		Recognition		✔	✔			
III. Prototyping	Planning investigations		Recognition		✔	✔			
Lesson 9: Refining Your Prototype									
I. Design and Complete Three Technical Tests	Constructing explanations, designing solutions	Explaining how the prototype works	Recognition						✔
	Planning investigations	Completing technical/social tests		✔			✔		✔
II. Optimize Design Based on Test Results	Developing and using models	Use sketch-up designs to discuss technical changes	Recognition	✔	✔	✔	✔	✔	✔
Lesson 10: Sharing Engineering Designs									
I. Creating Youth Engineering Cards	Constructing explanations, designing solutions; engaging in argument from evidence	Use final designs to explain how the invention works, what technical and social aspects it has, and how it uses scientific principles to reduce its environmental impact	Recognition	✔	✔	✔	✔	✔	✔
II. Making Videos			Recognition	✔	✔	✔	✔	✔	✔
III. Community Showcase			Recognition	✔	✔	✔	✔	✔	✔

ENGINEERING for
SUSTAINABLE COMMUNITIES

LESSON 1

How can classroom communities work together to engineer for sustainable communities?

Background for Teachers
In this lesson, students will recognize the EfSC principles as the guiding design principles for the engineering challenge of this unit. In preparation for this lesson, it is important to read the article *"Teaching Engineering for Sustainable Communities: An Equity-Oriented Approach"* from the teacher materials before starting this lesson. This article will be helpful as a reference for the remaining unit as well.

INTRODUCTION

DRIVING QUESTION

How can classroom communities work together to engineer for sustainable communities?

Overview

The purpose of this lesson is to introduce students to what engineering is and what engineers do. More specifically, teachers will introduce to students the concept of engineering for sustainable communities (EfSC). Using the case study of a human powered light-up desk, students will explore how EfSC core principles undergird the engineering design of the desk. Students use this case study to reflect on what is engineering for sustainable communities.

Lesson Standards

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.

Core Design Principles

Four principles are integrated across the i-Engineering unit and are intended to support teaching and learning of engineering practices from a sustainable communities' perspective:

1. Uses community members' ideas in engineering
2. Helps the community solve their problems through engineering
3. Cares about the environment
4. Designs solutions for now and in the future

Make sure to keep these principles in mind as you support students in systematically refining design constraints and evaluating possible solutions towards optimization in the unit.

Objective

Students will be able to define the criteria and constraints of an engineering problem by using the EfSC principles.

'I Can' Statement

I can define an engineering problem by using the EfSC principles.

Materials

- "Light-Up Desk" video
- EfSC Principles poster

Handouts

1A – Video Worksheet
1B – June's Light-up Desk & EfSC
1C – Reflection Worksheet

Equipment

None

KEY TERMS

Engineering Using science, math, and creativity to design solutions to solve problems

Sustainable Community A group of people that cares about each other and the environment and works together to make their community a better place. To the left, we list the core design principles for Engineering for Sustainable Communities.

LESSON SEQUENCE

I. Design Principles for Engineering for Sustainable Communities
II. Reflection & Assessment

PART I

Design Principles for Engineering for Sustainable Communities

A. Using the "Light-up Desk" video as an example, introduce engineering for sustainable communities (EfSC).

B. Introduction to the video: Tell students that this is a video about an 11-year-old girl, June, who decides to make a hand-crank-generator-powered light-up desk. She made it to solve a classroom community problem she has identified. Explain that she used a hand-crank generator to make power her design. As you watch the video, pay attention to:

a. What the problem is that June identified

b. Why the problem was important

c. What evidence she had for why it was important

d. Her solution, including how and why she made it the way she did

C. Show the light-up desk video.

D. Provide additional time for students to use the handout (1A) to reflect on what they noticed in the video.

E. Have a class discussion on what they noticed. Try to elicit student ideas about the problem, the evidence, and the solution. Ask how the lights were powered.

F. Next, introduce the EfSC principles and ask students how the video helps them to think about these ideas. Have them refer to handout (1B). You may want to show the video again to help students pick up ideas they might have missed. For example, June used her actual desk that was in her classroom, reusing community materials and saving money.

PART II

Reflection & Assessment

A. As a class, discuss what engineering for sustainable communities means.

B. Discuss how engineering for sustainable communities would look in their own life. Generate a list of ideas on the board.

C. To close this lesson, have students use handout (1C) to reflect on engineering for sustainable communities. You can have students work with shoulder partners and share their responses with them before working with the whole group.

Duration

1 Class Day

Lesson Notes

In Part I, Step F, keep track of your students' ideas on the front board in the classroom with a chart that aligns with activity sheet (1B).

TIPS

Students are capable designers of engineering solutions for real problems as sixth graders. As a teacher, during the video make sure you are celebrating June's agency, age, and ability to engineer with community.

Be sure to point out how June is thinking about a wide range of people in her community (young people, elderly) and their needs, and how she feels confident in solving their problems in collaboration with them (e.g., emails and surveys).

You can discuss connections between sustainability, the environment and green energy. Green energy is important because it is renewable, clean, and is good for the environment.

This activity can serve to address issues of under representation in the field of engineering related to gender or race.

VIDEO WORKSHEET

Name:

What is the problem that June wants to solve?

What is this problem important to June?

What is her solution, including how and why she made it the way she did?

What was the purpose of the solution?

ENGINEERING for SUSTAINABLE COMMUNITIES \\ **LESSON 1**

JUNE'S LIGHT-UP DESK & EFSC

Name:

Engineering for Sustainable Communities principle	What does this mean in your own words?	Ideas from the Video
1 USES COMMUNITY MEMBERS' IDEAS IN ENGINEERING		
2 HELPS THE COMMUNITY SOLVE PROBLEMS		
3 CARES ABOUT THE ENVIRONMENT		
4 FINDS SOLUTIONS FOR NOW AND IN THE FUTURE		

ENGINEERING for SUSTAINABLE COMMUNITIES \\ **LESSON 1**

REFLECTION WORKSHEET

Name:

DIRECTIONS

Share your thoughts about engineering for sustainable communities in the following sections drawing or writing what an engineer is for you and why engineering is important.

For me, an engineer for sustainable communities is someone who . . .	Engineering for sustainable communities is important because . . .	I have done engineering for sustainable communities when . . .
DRAW OR WRITE	DRAW OR WRITE	DRAW OR WRITE

HOJA DE TRABAJO DE VÍDEO

Nombre:

¿Cuál es el problema que June quiere solucionar?

¿Por qué este problema es importante para June?

¿Cuál es su solución? Incluye cómo y por qué ella lo hizo de la manera que lo hizo.

¿Cuál es el propósito de esta solución?

EL "ESCRITORIO ILUMINADO" DE JUNE & LA INGENIERÍA PARA COMUNIDADES SOSTENIBLES

Nombre:

Principios de ingeniería para comunidades sostenibles	Ent us propias palabras, ¿Qué significan estos principios?	Ideas del video
1 USA LAS IDEAS DE INGENIERÍA DE LOS MIEMBORS DE LA COMUNIDAD		
2 AYUDA A LA COMUNIDAD A SOLUCIONAR SUS PROBLEMAS A TRAVÉS DE LA INGENIERÍA		
3 SE PREOCUPA POR EL AMBIENTE		
4 DISEÑA SOLUCIONES PARA AHORA Y EL FUTURO		

HOJA DE TRABAJO DE REFLEXIÓN

Nombre:

INSTRUCCIONES

Comparte tus ideas acerca de la ingeniería para comunidades sostenibles en las secciones que siguen. Puedes dibujar o escribir que es un/a ingeniero/a para tí y por qué es importante la ingeniería.

Para mí, un/a ingeniero/a para comunidades sostenibles es alguie que . . . DIBUJA Y ETIQEUTA, O ESCRIBE	La ingeniería para comunidades sostenibles es importante porque . . . DIBUJA Y ETIQEUTA, O ESCRIBE	He hecho ingeniería para comunidades sostenibles cuando . . . DIBUJA Y ETIQEUTA, O ESCRIBE

ENGINEERING for
SUSTAINABLE COMMUNITIES

LESSON 2

How can we design and power electric art circuits?

Background for Teachers
In this lesson, students will be creating circuits, or closed loops through which electricity travels. Every circuit requires a power source. Electrons, or a particle with a negative electric charge, travels from areas of high electric potential to areas of low electron potential along a conductive path. The conductive path will be copper tape in this lesson, and the power source will be small coin batteries.

DESIGNING ELECTRIC ART

DRIVING QUESTION

How can we design and power electric art circuits?

Overview

In this lesson, students apply the engineering for sustainable community (EfSC) principles to their first engineering design challenge: creating electric art. Through this design challenge, students will understand how circuits work, including load (power requirement of the load, such as an LED light), switch, power source and the conductive element. As part of this, they will learn that circuits with more than one light bulb can carry different power requirements.

The iterative engineering design cycle will allow students to investigate how circuits work, design their own electric art, and share what they learn with each other and then optimize their design. This is a process that students will utilize multiple times throughout this unit.

Lesson Standards

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-ETS1-3: 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.

Objective

Students will design an electric art circuit.

'I Can' Statement

I can optimize an electric art circuit using our EfSC principles.

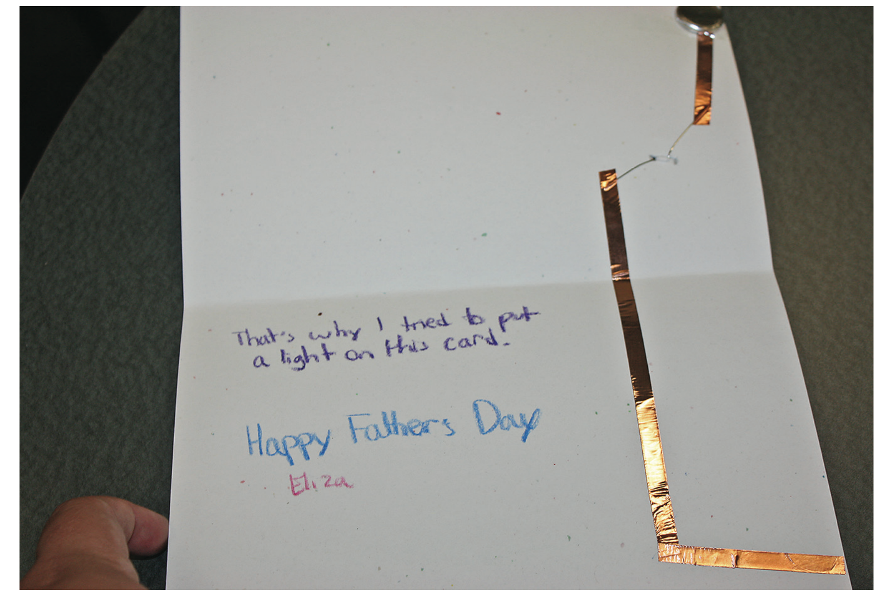
Materials

- Copper tape
- Cardstock
- Construction paper
- LED lights
- 3V batteries
- Scotch tape
- Masking tape
- Glue sticks
- Markers
- Scissors
- Colored pencils
- Craft sticks
- Washi tape
- Pipe cleaners
- Yarn

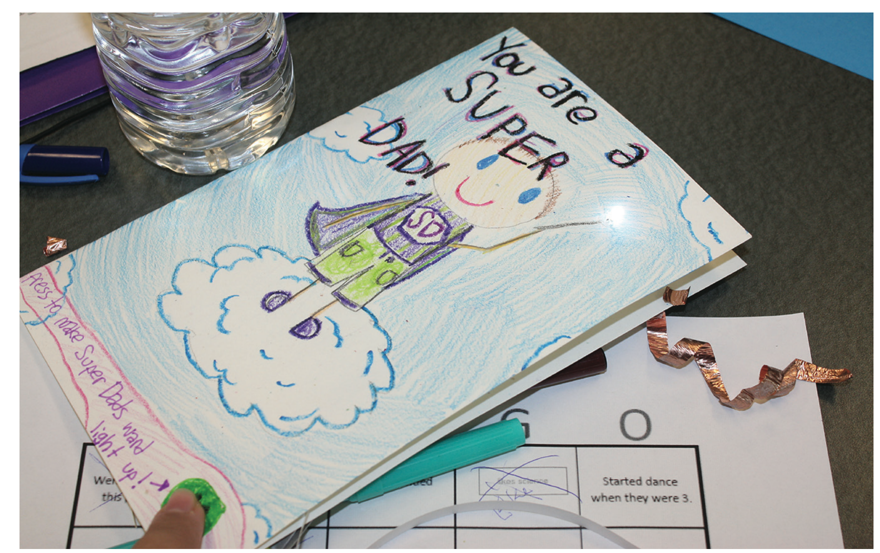
Handouts

2A – Interview Script
2B – Simple Circuit Group Worksheet
2C – Series Circuit Group Worksheet
2D – Parallel Circuit Group Worksheet
2E – Electric Art Checklist
2F – Electric Art Questions
2G – Electric Art Rubric

Electric Art Examples



Electric art can be two or three-dimensional. All electric art needs to have switches. Here is one example. When the card is closed, the copper tape touches the battery and completes the circuit.



This electric art's switch requires the user to press the button to complete the circuit.

Duration

3 Class Days

KEY TERMS

Circuit the path that electrons flow, that begins and ends in the same place

Current how much electricity is flowing through the circuit. A higher current means more electricity is flowing. Current is measured in amperes. The symbol for amperes is *A*.

Simple circuit a circuit that only has a single load, such as one light bulb or one noisemaker

Series electric circuit a circuit where the current passes through each load in a single branch in consecutive order

Parallel electric circuit a circuit where the current divides as it flows through separate branches and then is combined again

Voltage how hard electricity is being "pushed" through a circuit. A higher voltage means the electricity is being pushed harder. Voltage is measured in volts. The symbol for volts is *V*.

Kinetic energy energy of motion

Potential energy energy that is stored

KEY PARTS OF A CIRCUIT

Power source the energy source that powers the circuit

Load the electricity energy transferred in a circuit

Pathway the way electricity flows through a circuit

Switch the object that opens and closes a circuit to complete it

DESIGNING ELECTRIC ART

LESSON SEQUENCE

DAY ONE

I. Introduce the design challenge
II. Prototype 1: Electric art templates

DAY TWO

III. Prototype 2: Electric art cards

DAY THREE

III. Finish building electric art cards
IV. Share solutions and engineering discussion
V. Drawing and explaining electric art cards

PART I

Introduce the Design Challenge

A. Begin by saying, "You realized that you wanted to give a present to a friend or family member, but you forgot to buy something for them. You searched around your home and you found some odds and ends, including:

- LED light bulbs
- small batteries
- copper tape
- lots of craft supplies

B. Show the students the materials. Hold up the different items and ask students:

- Have they seen or used them before?
- What could these materials be used for?
- How can they be used?

C. Connect this engineering challenge to the engineering design cycle by pointing out different aspects of the engineering design cycle while asking:

- How will you design the card to help the person you give it to now and in the future?
- How does this help us care for our environment?
- How will you balance the technical dimensions of your card with community needs?

D. Observations

- Have students take a few minutes to observe the copper tape, lights, and battery.
- Have students share their observations and ask them how those observations might help them in their electric art circuit building.
- Record student responses on the board. See examples in box at right.

Participatory Planning Conversation Opportunity

Host a class discussion where the class decides who they make electric art for and for what purpose. Perhaps, students will want to make an electric art exhibit to decorate their classroom or nameplates for their desk. Maybe, they will want to work in pairs to make inspirational signs to display in the classroom or to give to younger students for their classrooms. They also may want to make their own electric art cards to share with loved ones.

TIP

It is important that students notice the + on the battery, understand that copper tape conducts electricity, and understand the different LED leads are +/–. Explain that the LED lead length shows positive (longer) and negative (shorter) ends.

EXAMPLE

Observation of Materials

Copper Tape: Shiny, metal sticky
Used for: connecting batteries and LED lights, electricity travels through copper tape

Battery: 3V, + on one side, so must be – on the other side
Used for: power source

LED lights: Long wire, short wire
Used for: long wire (+), short wire (–)

Ask students how they will turn their lights on and off. If they do not talk about switches, have them look at the light switch in their room. Show examples of switches on electric art cards.

A GOOD PROMPTING QUESTION

What do you think it means for your circuit if there is a + on the battery, and there are negative and positive leads?

Students should come up with two answers: 1) there must be a negative side of the battery and 2) there must be a reason why there are + and – in the circuit design. At first, have them explore this, but you may need to explain that electricity flows from high potential to low potential. Therefore, a +–+– pattern is necessary.

Then ask students to brainstorm: What could you do with these materials? Generate a list of possible ideas. Explain that they can make an electric card.

PART II

Prototype 1: Electric Art Templates

A. Have students form groups of three. Have an "Ask 3 before me" norm. This positions students as experts.

B. Show students the different electric art circuits (see right) and show the **video** in the slide show about how to complete the circuits on the templates.

C. Explain to the students that they are going to look at how the three different circuits are similar and different. Remind them that these differences will matter when they design their own electric art card.

D. Have students complete all three of their electric art templates.

E. In groups, have students complete the observation questions on the top of the templates. This work will help students to understand:

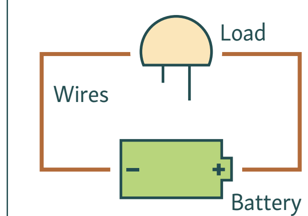
- the flow of electricity through circuits
- the transfer of energy in each circuit
- the differences between series and parallel circuits
- the necessary components of a circuit

F. Group discussion: Have a student show how the simple, parallel, and series circuits work. Have the class discuss the following questions:

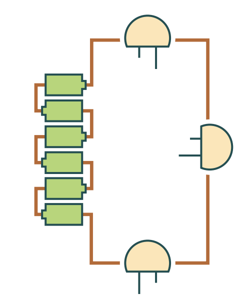
- What do all of the circuits have?
- How are the circuits different?
- How does the electricity flow through the circuit?
- What are the affordances of each circuit?

Circuit Types

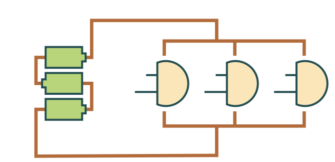
Simple Circuit
A series circuit with one load



Series Circuit
Electricity follow one path



Parallel Circuit
Electricity follows more than one path



PART III

Prototype 2: Build Electric Art Cards

A. Group discussion Generate a list of the necessary parts of a circuit and the affordances of series and parallel circuits. Ask students to brainstorm: what would they want to change to their original templates to turn them into a gift? (They will generate ideas like use different colors, make the circuit different shapes, personalize it, and fold it like a card.) Tell students that is what they will get to do now.

B. Show the slide that provides examples of electric art circuits that will not work. Have students explain why they do not work and how the energy is or is not transferred.

Example Responses

a. The battery needs to be connected to the copper tape, not wrapped around by the copper tape
b. The battery can't connect directly to the battery
c. The copper tape needs to go in on loop
d. Copper tape must touch the bottom and top of circuit
e. Short circuit failure mode

C. Show the three examples of different cards and put them in places for youth to go and see the cards, but not take them back to their work areas. Make sure to point out the 3 different types of switches.

D. Sketching Plan and Feedback Interview

- Have students draw their circuit on the electric art card. Have them include the switch, power source, light and pathway. Have students check their design with their classmates then show the design to teacher.
- Have students complete the pre-interview script by explaining how their design works and who it is for.
- Have students draw their circuit on the electric art card. Have them include the switch, power source, light, and pathway. Have students check their design with their classmates then show the design to teacher.
- Have students complete the pre-interview script by explaining how their design works and who it is for.
- Once students have their design approved by the teacher, they should receive about 20 inches of copper
- Have students build and test their electric art card.

If any students finish early:

- Have them help other students
- Complete their analysis handout (2G)
- Have students try using different switches or 3D art instead of 2D art

Lesson Notes

Often kids just put the light leads on the battery and make it work. This is a good first step, but push them further by having them include copper tape.

Building will take most students two lessons. Have students store their works-in-progress in zip bags with their names on them. Keep them in the classroom. They will use those materials in the next class.

TIPS

Cut tape with scissors to avoid copper tape cuts.

Press hard and rub the copper tape when it is over the light wires.

The longer lead on the LED light is the positive connection; the shorter lead is the negative connection.

No copper tape should be directly under the bulb.

Guidelines

a. Like electric art prototype 1, draw the circuit on your electric art. Raise your hand to have your teacher check your design and get the materials.
b. Must use copper tape
c. Light cannot be directly attached to the battery
d. Must have an on/off switch
e. Can use up to two LED lights

PART IV

Share Solutions and Engineering Discussion

A. Showcase Have students show their cards to the class. Then draw and explain their designs at the same time on the board. Make sure students answer these questions:

- How did you get your circuits to work?
- Where is the switch?
- In what direction does the electricity flow?
- What problems did you encounter and how did you solve them?

PART V

Drawing and Explaining Electric Art Cards

A. Explain to students that engineers need to share their designs. Ask them what they think makes a good design. Answers should include things like: it needs to be clear, labeled, specific. Others should be able to take your design and build it.

B. Have students draw and label their final electric art design

C. Have students write down how their circuit works (technical specifications).

D. Have students explain why they think the person who is getting the electric art will like it (social specifications).

TIPS

Have as many students share their designs as possible so they can be recognized for their work.

Encouraging and valuing the encountering and solving of problems recognizes students engage in the engineering practices of designing solutions.

INTERVIEW SCRIPT

Name:

DIRECTIONS

1. Complete the interview script. **2.** Interview at least two people. **3.** Make changes to your electric art card sketch based on the interviews. **4.** Make your electric art card.

This is my electric art design. It uses a ____________________ (simple, parallel, series) circuit to light up ________ (1, 2) bulbs.

Write a description of how it works:

Show the interviewee how the electricity will flow across your circuit.

Do you think this design will work? Why?	Take interview notes here:

I am making this design for ________________________ . Here are some details that I added to make sure they like it:

a. ____

b. ____

c. ____

Do you think they will like it? What else can I do to make it better for them?	Take interview notes here:
Write one more question you would like others to give you feedback on for your card design:	Take interview notes here:

CHECKLIST

1. Who did you interview? ____
2. Did you make changes to your electric art card sketch based on the interviews? ______________
3. Let your teacher know so you can start making your electric art card.

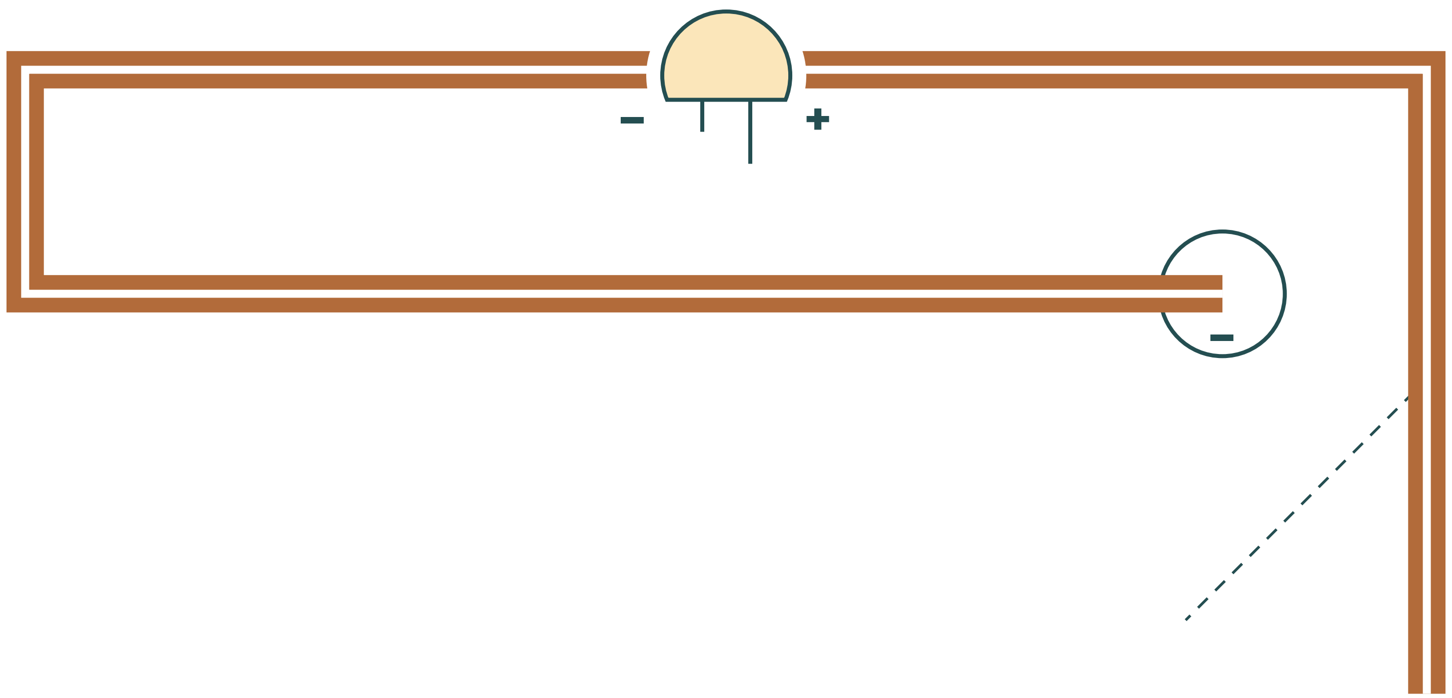
SIMPLE CIRCUIT

Name: ______________________

Group Members: ______________________

____

____



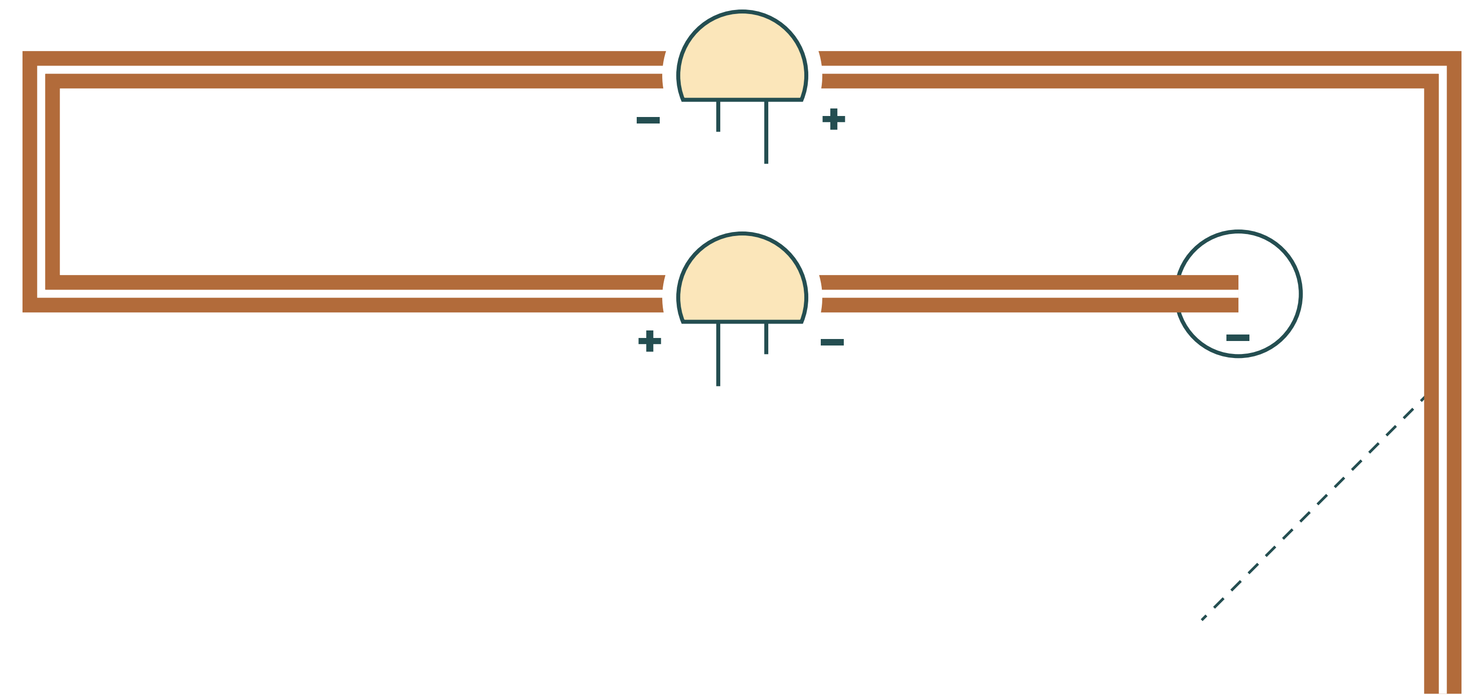
SERIES CIRCUIT

Name: ______________________

Group Members: ______________________

____

____



DIRECTIONS

1. Did your two lights light up? ______________
2. Were they as bright as in a simple circuit? If not, how could you make them bright?

   ____

3. Show the flow of electricity with an arrow and label on the template.
4. Label the components of the circuit: power source, load, switch, and pathway.

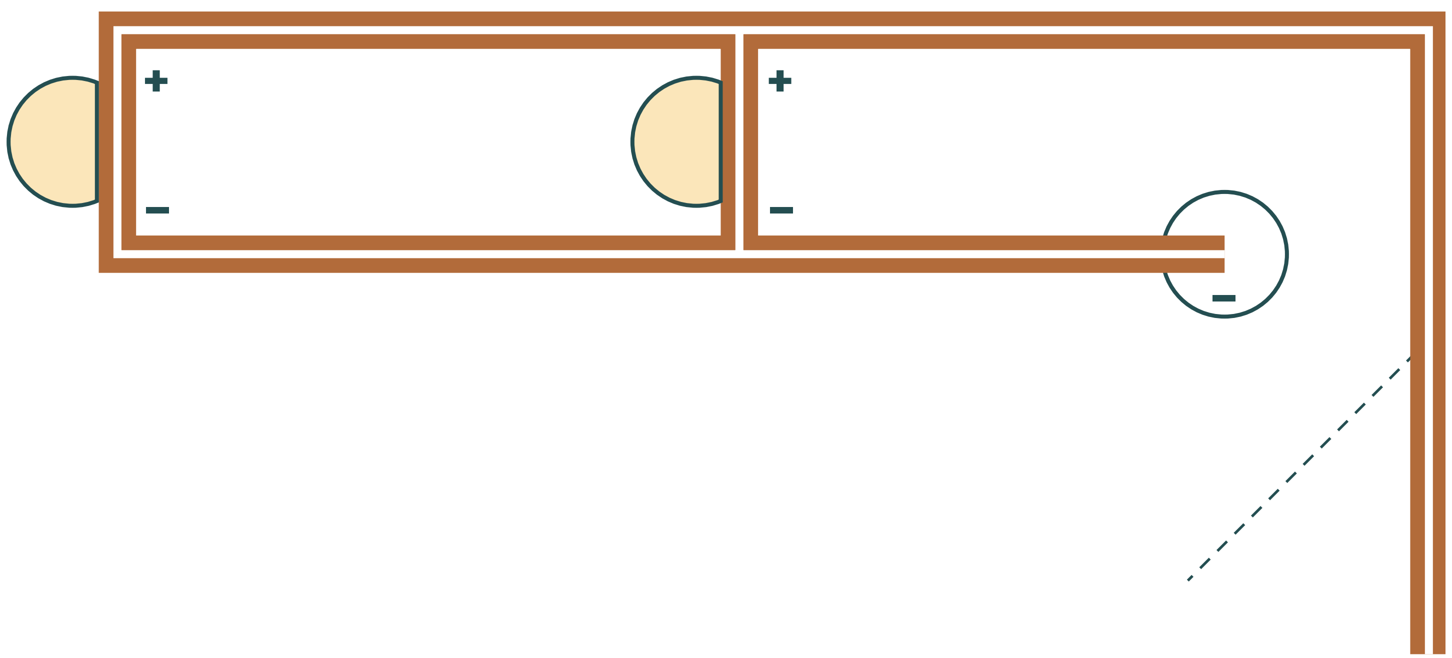
PARALLEL CIRCUIT

Name: ____________________

Group Members: ____________________

____

____



DIRECTIONS

1. Did your two lights light up? ____________

2. Were they as bright as in a simple circuit? If not, how could you make them bright?

____

3. Show the flow of electricity with an arrow and label on the template.

4. Label the components of the circuit: power source, load, switch, and pathway.

ELECTRIC ART CHECKLIST

Name: ____________________

INSTRUCTIONS

1. Draw and label your electric art circuit.

2. Label: Copper tape, LED light, battery, switch, current flow (use arrows).

CHECKLIST

My design uses:

- ❐ A battery
- ❐ A LED light bulb
- ❐ Copper tape
- ❐ Has a switch

ELECTRIC ART QUESTIONS

Name:

QUESTIONS

How does your design work? (Make sure to discuss the energy transformations)

Who is going to receive your electric art?

Why do you think they will like your electric art?

ELECTRIC ART RUBRIC

Name:

Lesson Objective: Students will design an electric art circuit

I-Engineering Big Ideas		Criteria	Is this present?			Feedback
			No Evidence	Evidence Present	Strong Evidence	
Engineering for Sustainable Community Principles	Uses community members' ideas in engineering	Modified design based on classmate, community member and teacher feedback				
		Tailored the social and technical aspects of the card for its intended purpose (Made the card in a way they knew the person they were giving it to would like it.)				
Energy Practices	Designing Solutions	Utilized social design aspects to help solve a problem				
		Designed a working circuit				
Energy Content Knowledge	Types of Energy	Explain that the battery was the source of energy				
	Energy Flow	Labeled the components of a circuit (switch, pathway, load, battery)				
	Energy Transformation	Explained/labeled the direction flow through the parallel or series circuit				
		Explained how energy was transferred in the circuit				

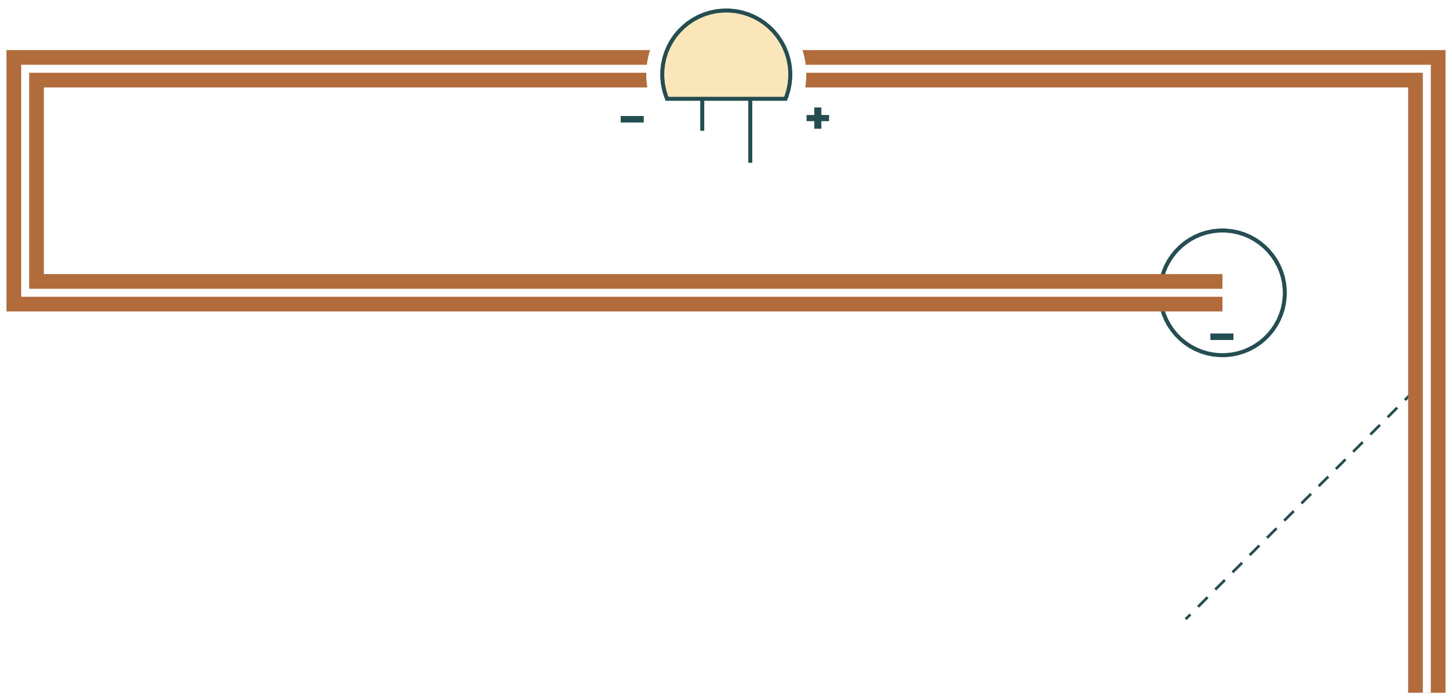
CIRCUITO SIMPLE

Nombre:

Miembros del grupo: ___________________________

____

____



CIRCUITO EN SERIE

Nombre:

Miembros del grupo: ___________________________

____

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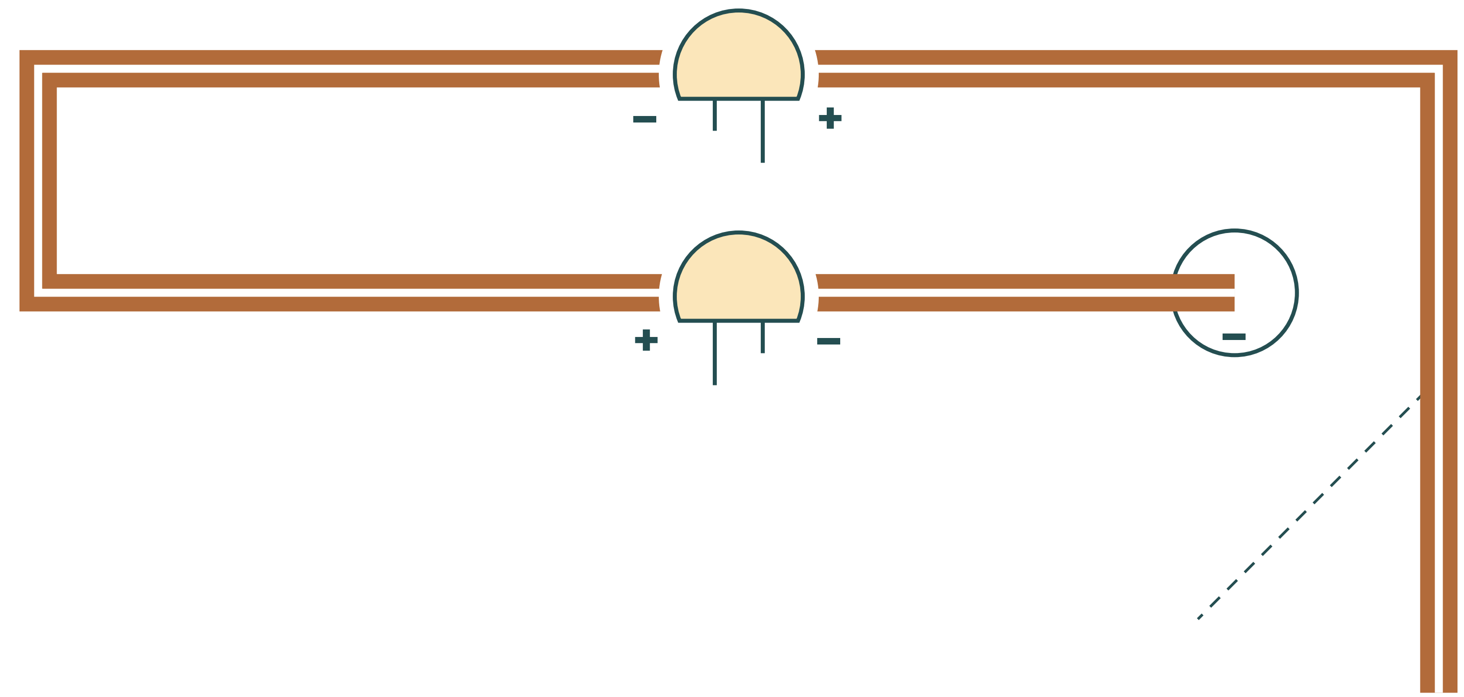


INSTRUCCIONES

1. ¿Se encendieron ambas luces? _______________
2. ¿Brillaban igual que en un circuito simple? Si no, ¿qué harían para que brillen más?

   ____

3. Demuestren el flujo de la electricidad con una flecha y un rótulo en el modelo.
4. Identifiquen los componentes del circuito: fuente de energía, carga, interruptor y conductor.

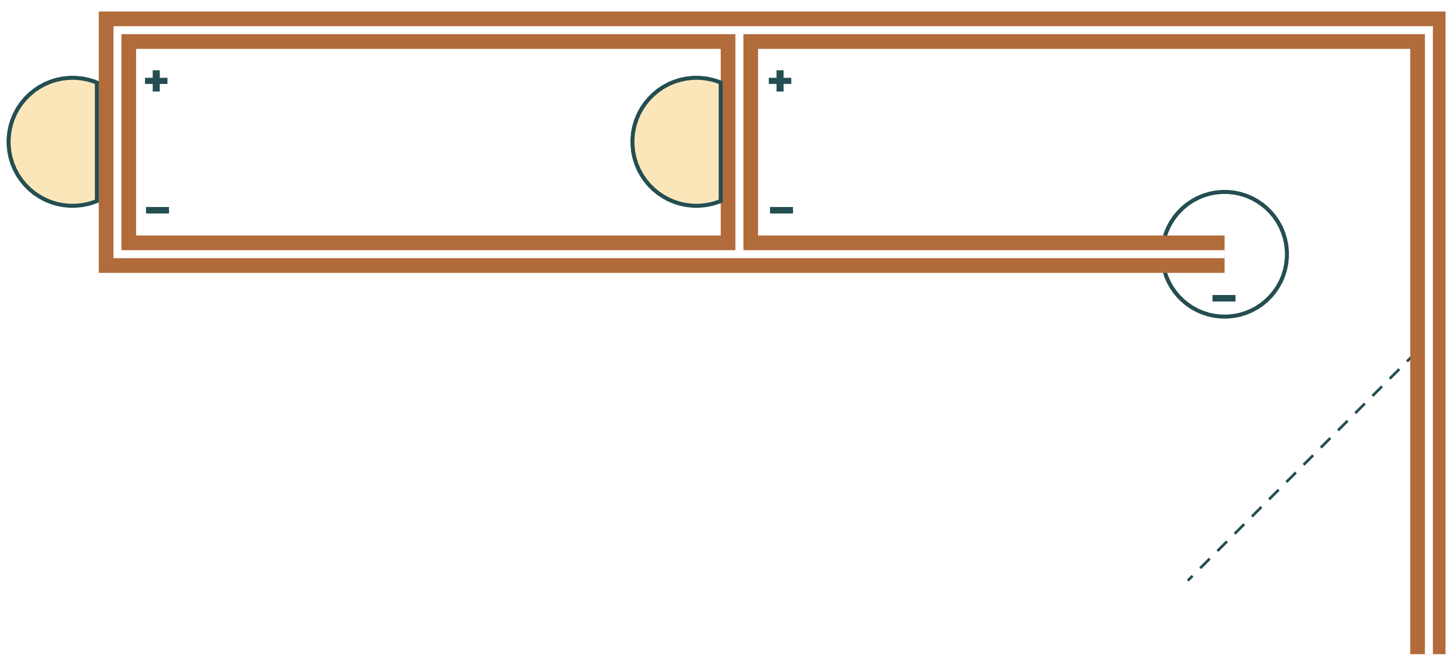
CIRCUITO DE PARALELO

Nombre:

Miembros del grupo: ______________________

____

____



INSTRUCCIONES

1. ¿Se encendieron ambas luces? ____________
2. ¿Brillaban igual que en un circuito simple? Si no, ¿qué harían para que brillen más?

____

3. Demuestren el flujo de la electricidad con una flecha y un rótulo en el modelo.
4. Identifiquen los componentes del circuito: fuente de energía, carga, interruptor y conductor.

LISTA DE COTEJO PARA ARTE ELÉCTRICO

Nombre:

INSTRUCCIONES

1. Dibuja y rotula tu circuito de arte eléctrico.
2. Identifica: la cinta de cobre, la bombilla LED, la batería, el interruptor y el flujo de corriente (usa flechas).

LISTA DE COTEJO

Mi diseño usa:

- ❒ Una batería
- ❒ Una bombilla LED
- ❒ Cinta de cobre
- ❒ Un interruptor

PREGUNTAS PARA ARTE ELÉCTRICO

Nombre:

PREGUNTAS

¿Cómo funciona tu trabajo de diseño? (Asegúrate de discutir las transformaciones energéticas.)

¿A quién le regalarás tu obra de arte eléctrico?

¿Crees que le gustará tu obra de arte eléctrico?

RÚBRICA PARA ARTE ELÉCTRICO

Nombre:

Objetivo de la lección: Los estudiantes diseñarán un circuito de arte eléctrico.

i-Grandes ideas de ingeniería		Criterios	¿Esto se encuentra?			Comentarios
			No hay evidencia	Hay evidencia	Evidencia sólida	
Principios de ingeniería para una comunidad sostenible	Usa las ideas de ingeniería de los miembros de la comunidad	Modifica el diseño basado en los comentarios de los compañeros de clase, miembros de la comunidad y el maestro				
		Ajusta los aspectos sociales y técnicos de la tarjeta para su propósito deseado (Hizo la tarjeta pensando en los gustos de la persona a quien se la regalaría.)				
Prácticas energéticas	Diseño de soluciones	Usa aspectos sociales del diseño para ayudar a solucionar el problema				
		Diseña un circuito de trabajo				
Conocimiento de contenido energético	Tipos de energía	Explica que la batería era la fuente de energía				
	Flujo de energía	Identifica los componentes de un circuito (interruptor, conductor, luz o carga, batería)				
	Transformación energética	Explica o identifica la dirección del flujo de electricidad por el circuito en paralelo o en serie				
		Explica cómo la energía fue transferida al circuito				

ENGINEERING for
SUSTAINABLE COMMUNITIES

LESSON 3

How can we use alternative energy sources to power paper circuits?

Background for Teachers

In this lesson, students will first distinguish between renewable and non-renewable resources. In particular, they will first focus on batteries to connect with their circuit artwork. Then they will discuss coal in connection to the largest source of electricity production in Michigan and North Carolina. By doing this, students will be able to build off their previous work, and also will be able to use this knowledge to think more about their community energy production and practices. Then students will explore the law of conservation of energy and energy transformations.

SUSTAINABLE ELECTRIC ART

DRIVING QUESTION

How can we use alternative energy sources to power paper circuits?

Overview

The purpose of this lesson is to investigate how to power paper circuits with alternative energy. In this lesson, students will distinguish between renewable and non-renewable energy sources. Students will also investigate different forms of energy transformations to power their paper circuit: mechanical (hand crank), solar (solar panel), and piezoelectric pads. Additionally, they will also weigh social and environmental trade-offs for each source of energy. In the end, they will optimize their paper circuit designs to utilize a green energy source.

Lesson Standards

MS-PS3-5: Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.

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.

Objective

Students will analyze the affordances and constraints of both parallel and series circuits powered with alternative energy.

'I Can' Statement

I can choose the best alternative power source based on the principles of engineering for sustainable communities to power my electric circuit.

Materials

- 3 Sets of 3 Cards (1 light in simple circuit, 3 lights in series circuit, 3 lights in parallel circuit)
- Previously created electric circuit cards

Handouts

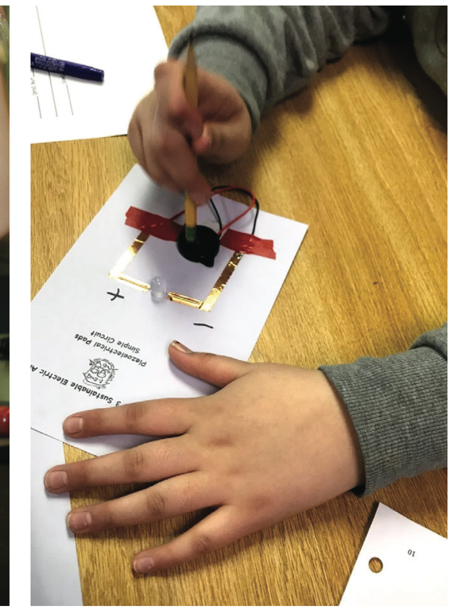
3A – QR Code Videos
3B – Green Energy Stations Data
3C – Trade-off Explanations

Equipment

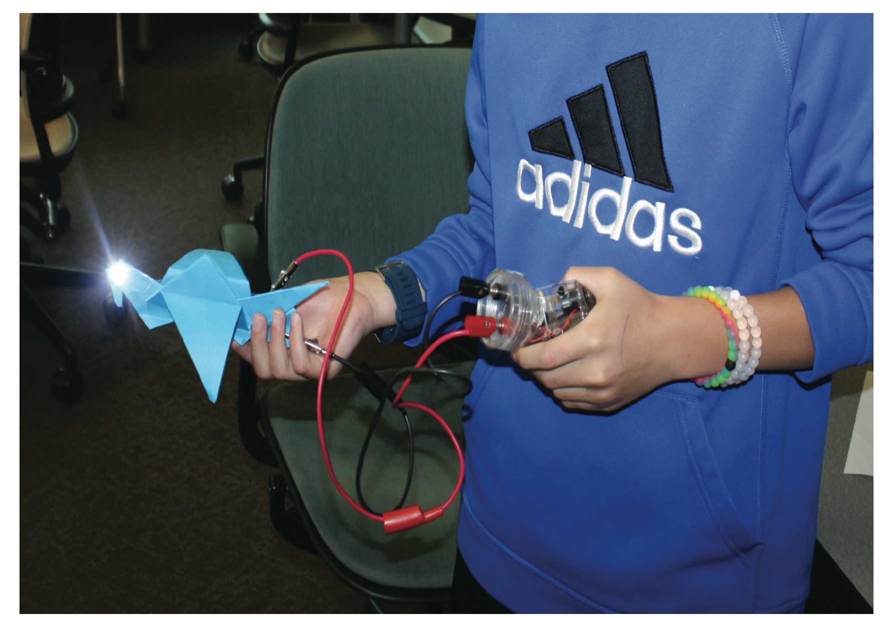
- Scissors
- Hand cranks
- Solar panels
- Piezoelectric pads
- Lamp *(In case it is too dark for solar panels to work on their own)*

Examples of what parts of the lesson may look like:

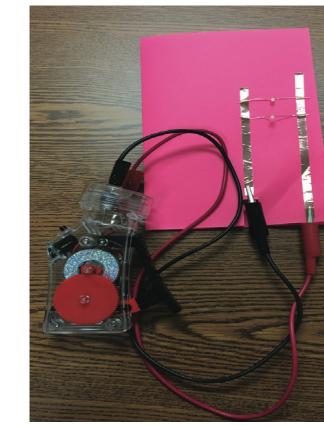
Students will be able to kinesthetically explore what one watt of energy is. This is key for the rest of the unit. Have students rotate in groups from station to station.



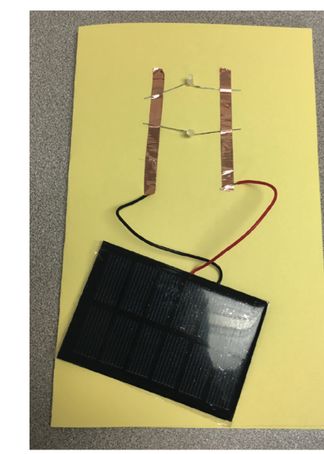
At each station, they will watch a video about a green energy source. Then they will explore it with the materials at the station. Above, a student works at the solar energy station.



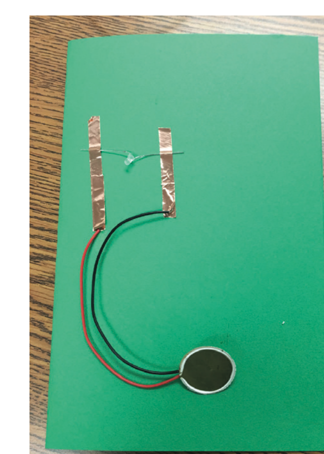
After students complete all of the stations, they will balance the trade-offs for the different energy sources. Then, they will try out lighting their electric art with a green energy source. Students simply connect the green energy source to the batteries to light up their cards.



Hand-crank generator



Solar panel



Piezoelectric pad

SUSTAINABLE ELECTRIC ART

LESSON SEQUENCE

I. What is energy?
II. How do we produce energy?
III. Renewable energy stations
IV. Comparing trade-offs of different energy sources

PART I

What is energy and is it different?

A. Apple/book demo: Have a volunteer come to the front of the room. Show them and the class the length of a meter stick, and ask the volunteer to lift the apple or book up and down at the pace of 1 lift per second. While the volunteer does the lifting motion, discuss with the class:

- We powered our cards with batteries correct, why did we do that? Students should answer: It gave our card energy. Then follow up with, "what is energy?
- Have student lifting the apple lift continue to lift throughout the conversation.
- After the conversation is over, ask the student what they were doing? The responses will vary, but discuss with them: If you lifted this for one full minute, you are using enough energy to power one two light electric art card for seven minutes.

DISCUSSION

What is energy?

Students should be able to explain that energy is the ability to do work. Have them list examples of doing work (e.g. lifting the apple, lighting lights, ringing a bell).

B. Energy transformation demo: Have students touch their palms to their face. Then have them rub their hands together quickly for 30 seconds. Ask them to touch their palms to their face again.

- Ask for observations about the differences between when they touched their hands to their face before and after rubbing their hands together.
- Ask for examples of when energy was being used during the exercise.
- Ask them to explain how the energy transformed during the exercise (e.g. the moving of hands; the heating of hands).
- Ask students to explain other energy transformations they listed previously. (e.g. electrical energy converted to light and heat energy when the switch was flipped.

Duration

1 Class Day

Lesson Notes

You can play videos using the QR codes provided on the next lesson page. Each video is an example of the three renewable energy sources (Hand Cranks, Solar Panels and Piezoelectric Pads).

KEY TERMS

Trade-offs One important aspect of what engineers do every day is to analyze and improve efficiency. By making changes to technology and human processes, engineers are always trying to think of new ways to save us time, energy, materials and costs. Engineers also look for ways to save people time in their daily lives by making "trade-offs." A trade-off occurs when we sacrifice one thing to gain something else that we value more. Trade-off decisions are made for social, environmental and sometimes economic benefits.

Energy The ability to do work. There are many forms of energy, such as electrical, chemical, human, and solar.

Potential energy Stored energy

Green (Renewable) Energy Energy that is collected by renewable resources and naturally replenished on a human time scale. Green Electrical Energy is electricity that is created from renewable resources..

The law of conservation of energy Energy is never lost in a system, it just changes its form. For example, electricity is a form of energy. It is changed from electric energy to both heat and light energy when a desk lamp is lit.

PART II

How Do We Produce Energy?

A. What ideas have we heard about energy that are good for the environment?

B. Say we are now going to watch a video. We know that energy is transferred from one form to another, specifically explaining how energy is transferred often to get us electricity in Michigan. This will remind us why these renewable energy sources are important for the environment. **Watch:** *https://www.youtube.com/watch?v=9Wv2GKaukZU*

C. Ask: Given what you have learned here, what are the advantages of using renewable forms of energy? If possible, write the answers on the board.

D. As a class, look at the image of the power plant in the slide show. Discuss how the energy transfers as energy in coal is transformed into electricity and note the potential environmental impacts at each step. Model the first two steps as a class, then have students work in pairs to explain the energy transformations.

- **Ask:** What energy transformation occurred? What is missing from this video about burning coal? Other than heat, what else is produced? Carbon dioxide, particulates and harvesting fossil fuels are all problems.
- **Discuss:** Is coal a sustainable and a renewable resource?

E. Goal: Energy changes form, and in the changing of form it impacts the environment. We want minimum environmental impact.

PART III

Renewable Energy Stations

A. Explain that there are many other ways to transform energy into electricity. In this lesson, we will use three sources of renewable energy sources (solar panels, piezoelectric pads and hand cranks) to power our electric art circuits. Lift up each energy source and demonstrate how it works.

- **Hand crank:** Hand cranks contain generators that convert mechanical energy into electrical energy. Make sure to explain that they can overcrank the hand crank and that they need to use it gently or it will break.
- **Solar Panel:** Solar energy is radiant energy emitted by the sun or power obtained by harnessing the energy of the sun's rays. The panels store this energy until it is transformed into electricity.
- **Piezoelectric Pads:** Vibrational energy is converted into electricity with these Vibrational energy is a type of mechanical energy.

B. Discuss with students the possible impacts from various types of electricity generation on the environment. Ask students: "What is better for the environment: renewable or nonrenewable energy sources?"

KEY TERMS

Additional information about green energy sources and the type of energy they use:

Mechanical (Hand Crank) In electricity, a generator is a device that converts mechanical energy (the sum of potential energy and kinetic energy and is the energy associated with the motion and position of an object) into electrical energy for use in a circuit.

Solar (Solar Panel) Solar energy is radiant energy emitted by the sun or power obtained by harnessing the energy of the sun's rays. The panels store this energy until it is transformed into electricity.

Mechanical (Piezo electrical) Vibrational energy is converted into electricity with these. Vibrational energy is a type of mechanical energy.

SUSTAINABLE ELECTRIC ART

C. Tell students that when they visit each station they will try to decide the best way to power their paper circuits using different green energy sources and will document the different trade-offs of each source.

1. Divide your class into six groups.
2. Review your group work expectations.
3. Have each group start at a different station with technology to watch the kid-made video and try out the energy sources with each of the energy sources with the electric art circuits at the station. The kid-made videos are embedded in the slideshow.
4. Have students' record their observations for each energy source.
5. Have student groups rotate to a new station after 10-12 minutes.

D. As you circulate around the room, prompt students to think about the trade-offs of each energy source in terms of:

- **Functionality:** Is it easy to use? Is it practical? Does it look the way you want it to?
- **Environmental Impact:** How would this energy source affect the environment?
- **Efficiency:** How hard do you need to work?

PART IV

Comparing Trade-offs of Different Types of Energy Sources

A. Have students work in groups to compare and contrast their findings. Have them generate trade- off explanations for each energy source.

For example, the hand crank was the easiest to assemble (PRO)*, but it was the hardest to sustain because I had to keep cranking and my hand got tired* (CON).

B. Discuss the findings of the groups as a whole class.

C. Have students explain what type of alternative power source to use with their electric art using evidence from the stations and engineering for sustainable community principles.

TIPS

The stations give students more autonomy in the classroom.

The students will not be able to light up all of the cards at every station because series circuits have a higher power requirement than parallel circuits.

Asking students one-on-one questions recognizes their expertise

If groups have similar answers, make them read theirs and start by saying "our answer was the same as group two because we said . . ." This will help in repeating important information and also by students recognizing others' groups contributions as well as their own.

ENGINEERING for SUSTAINABLE COMMUNITIES \\ LESSON 3

QR CODE VIDEOS

Name:

THREE RENEWABLE ENERGY SOURCES

Hand Crank Generator Video	Solar Panel Video	Piezoelectric Pad Video
tinyurl.com/y6m75pg4	*https://goo.gl/NYbls8*	*https://goo.gl/p1izTS*

1. Watch the videos
2. Try using the energy source to light the three different circuits
3. Record your observations

Video de generador movido a mano	Video del panel solar	Video de la almohadilla piezoeléctrica
tinyurl.com/y6m75pg4	*https://goo.gl/NYbls8*	*https://goo.gl/p1izTS*

1. Ve el videos
2. Intenta usar la fuente de energiá para encender los tres circuitos.
3. Graba tus observaciones.

GREEN ENERGY STATIONS DATA

Name:

	Hand Crank	Solar Panel	Piezoelectric Pads
What was the original form of energy before it was transformed into electrical energy?			
How practical/easy is it to turn on the lights?			
Can you turn on one light in a simple circuit?			
How bright was it?			
Can you turn on three lights in a series circuit?			
How bright was it?			
Can you light-up three lights in a parallel circuit?			
How bright was it?			
Other considerations (e.g., does it look cool, are the materials easy to get, etc.)			

TRADE-OFF EXPLANATIONS

Name:

In this section, generate trade-off explanations for each energy source. For example:

The battery powered the most lights, (PRO)
but it is not a renewable energy source. (CON)

HAND CRANK

The hand crank ______________________________

______________, (PRO) but______________________________

______________________________. (CON)

SOLAR PANEL

The solar panel ______________________________

______________, (PRO) but______________________________

______________________________. (CON)

PIEZOELECTRIC PAD

The piezoelectric pad ______________________________

______________, (PRO) but______________________________

______________________________. (CON)

DATOS DE ESTACIONES DE ENERGÍA VERDE

Nombre:

	Manivela	Panel solar	Almohadilla piezoeléctrica
¿Cuál era la forma de energía original antes de que se transformara en energía eléctrica?			
¿Cuán práctico o fácil fue encender las luces?			
¿Puedes encender una luz en un circuito simple?			
¿Cuań brillante era?			
¿Puedes encender tres luces en un circuito en serie?			
¿Cuań brillante era?			
¿Puedes encender tres luces en un circuito en paralelo?			
¿Cuań brillante era?			
Otras consideraciones (por ejemplo, se ve bien, los materiales son fáciles de conseguir, etc.)			

EXPLICACIONES DE LAS VENTAJAS Y LAS LIMITACIONES

Nombre:

En esta sección, explica las ventajas y las limitaciones de cada fuente de energía. Por ejemplo:

La batería alimentó la mayoría de las luces, (PRO)
pero no es una fuente de energía renovable. (CONTRA)

MANIVELA

La manivela ____________________

____________________, (PRO) pero ____________________

____________________. (CONTRA)

PANEL SOLAR

El panel solar ____________________

____________________, (PRO) pero ____________________

____________________. (CONTRA)

ALMOHADILLA PIEZOELÉCTRICA

La almohadilla piezoeléctrica ____________________

____________________, (PRO) pero ____________________

____________________. (CONTRA)

ENGINEERING for
SUSTAINABLE COMMUNITIES

LESSON 4

What are the steps I need to take to engineer for sustainable communities?

Background for Teachers
In this lesson, students will recognize the EfSC principles as the guiding design principles for the engineering challenge of this unit. In preparation for this lesson, you can read the article “Teaching Engineering for Sustainable Communities: An Equity-Oriented Approach” from the teacher materials before starting this lesson. This article will be helpful as a reference for the rest of the unit as well.

ENGINEERING DESIGN CYCLE

DRIVING QUESTION

What are the steps I need to take to engineer for sustainable communities?

Overview

The purpose of this lesson is to apply the engineering for sustainable community principles to the engineering design cycle. In order to do this, students will:

- Watch a video about other youths' sustainable engineering designs
- Analyze the youths' application of the engineering design cycle and engineering for sustainable community principles

Lesson Standards

MS-ETS1-2: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

Core Design Principles

Below we highlight core design principles for Engineering for Sustainable Communities (EfSC) that are integrated across the unit, and are intended to support teachers in teaching engineering practices from this perspective.

1. Uses community members' ideas in engineering
2. Helps the community solve their problems through engineering
3. Cares about the environment
4. Designs solutions for now and in the future

Make sure to keep these principles in mind as you support students in systematically refining design constraints and evaluating possible solutions towards optimization in the unit.

Objective

Students will be able to explain how they can engineer for sustainable community using the engineering design cycle.

'I Can' Statement

I can apply engineering for sustainable communities principles to the engineering design cycle.

Materials

- Occupied video
- Occupied postcard

Handouts

4A – Design Cycle

KEY TERMS

Sustainability caring about making positive environmental impacts while creating long term solutions for the community.

LESSON SEQUENCE

I. The Occupied Bathroom Alert video and analysis
II. Linking EfSC with the Engineering Cycle

PART I

The Occupied Bathroom Alert video and analysis

A. Introduce the Occupied Bathroom Alert video and postcard. The video and postcards were made by Mateo, Tryn and Meg, all 6th graders, who engineered an "Occupied Bathroom Alert" for their community using a sustainable energy source. As you watch the video, think about the following questions (which are on the back of the postcard):

1. How did this video inspire you?
2. What problem did the "Occupied" group members identify?
3. What was their solution?
4. What data did the "Occupied" group members use when creating their innovation?

B. In groups of four, discuss the questions on the back of the postcard.

C. After small discussion, discuss each question as a whole class. You can write this information on the white board as it will help your varying perspectives about competing design solutions, criteria, and constraints for design

D. Hand out the engineering design cycle to each of the students. Additionally, project the map on the white board. Use the map to discuss the "Occupied" group members' bathroom alert project. Have students write key ideas for each of the questions below on their design cycle map.

DISCUSSION

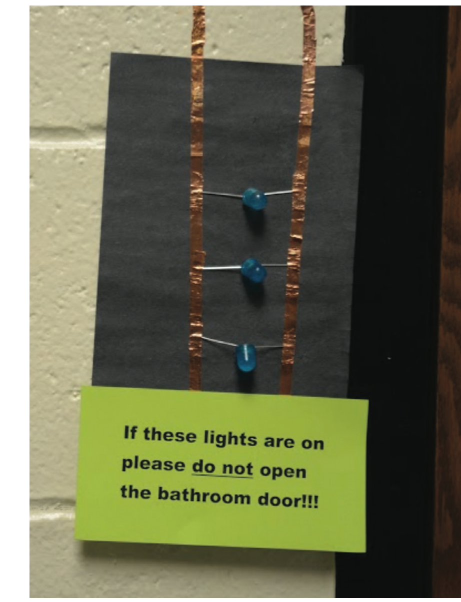
What was the problem that the "Occupied" group members tried to solve?

What community perspectives did Stephan consider? How did he find out those perspectives?

What are some design features of their bathroom alert system? (e.g. number of lights, brightness, energy source, background color, words, etc.)

Duration

1 Class Day



The Occupied Bathroom Alert System

TIP

The video and what inspires youth is a good place to highlight identity work. Not all youth will be inspired by the same things, and valuing all of the different entry points to engineering and what inspires young people to engineer is important.

ENGINEERING DESIGN CYCLE

E. After they built their bathroom alert system, what tests did they do to determine how well their bathroom alert system addressed their problem?

- Why did he do some of these tests?
- What technical data did he get?
- What social data did he get?

F. Adjusting the engineering design cycle based on the design principles of engineering for sustainable communities

PART II

Linking EfSC with the Engineering Cycle

A. How is the “Occupied” group members’ bathroom alert system an example of engineering for sustainable communities? (See core principles.) Have students add their ideas to the bottom box on the map.

B. How do you think this engineering cycle helped the “Occupied” group members make their project for sustainable communities?

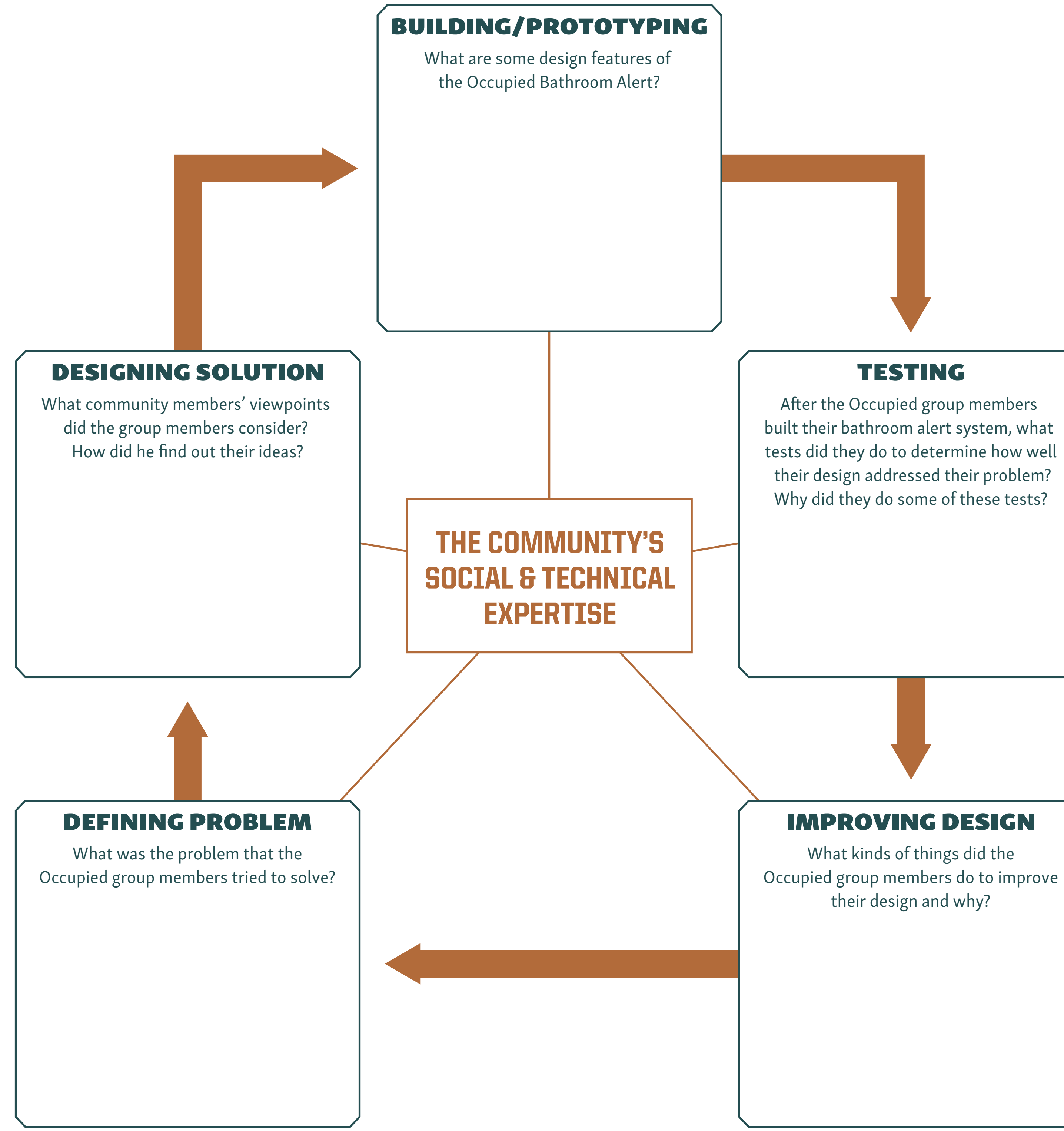
TIPS

When you discuss the community perspectives, pay attention to the different stakeholder groups that the students identify. It is important for them to see how engineering sustainable communities incorporates many different perspectives from different community members.

It is important to emphasize what kids can do. For example, in one implementation one of the sixth-grade girls said “Wow, if other kids can do this, then I can too!”

DESIGN CYCLE

Name:



CICLO DE DISEÑO

Nombre:

CREACIÓN DE PROTOTIPOS

¿Cuáles son algunas características del diseño del sistema de alerta de baño de los miembros del Occupied grupo?

PRUEBAS

Luego de que los miembros del Occupied grupo construyeran su sistema de alerta de baño, ¿qué pruebas llevaron a cabo para determinar cuán bien su diseño atendía el problema? ¿Por qué llevaron a cabo algunas de esas pruebas?

MEJORANDO EL DISEÑO

¿Qué tipos de cosas hicieron los miembros del Occupied grupo para mejorar su diseño y por qué?

DEFINIENDO EL PROBLEMA

¿Cuál fue el problema que intentaron solucionar los miembros del Occupied grupo?

DISEÑANDO LA SOLUCIÓN

¿Cuáles puntos de vista de los miembros de la comunidad tomaron en consideración los miembros del grupo? ¿Cómo se enteraron de sus ideas?

LA EXPERIENCIA SOCIAL Y TÉCNICA DE LA COMUNIDAD

ENGINEERING for SUSTAINABLE COMMUNITIES

LESSON 5

What important community problems can I solve using engineering?

Background for Teachers

In this lesson, students will understand what kind of information they need to define a local community problem. Then they will work together to administer a survey that provides insight to local community challenges that can be solved with engineering. The survey will allow students to differentiate between student and adult responses. When you share the results with the students, you can have the data sorted by the responses to question 1.

DESIGN CHALLENGE

DRIVING QUESTION

What important community problems can I solve using engineering for sustainable communities?

Overview

In this lesson students are introduced to the design challenge of making their classroom a sustainable place. After initially discussing what it means to make their classroom sustainable, students begin to gather data from school community members on the problems they feel are important. They do this through a survey that they give to both peers and adults connected to their school community.

Lesson Standards

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.

Objective

Students will define a problem that matters to their school community that they can solve within the constraints of the design challenge.

'I Can' Statement

I can define a problem that matters to my community that I can solve through engineering.

Handouts

5A – Kids & Adults Results
5B – Community Survey
5C – Community Survey Analysis

Equipment

iPads or computers for administering survey

KEY TERMS

Technical aspects a set of requirements that a product must meet, such as size, workload, number of parts, power requirements, etc.

Social aspects information from the community about the desired specifications of the product, such as easy to use, helpful to people, does not cost a lot, makes the community happier or healthier

LESSON SEQUENCE

DAY ONE

I. Engineering design challenge introduction
II. Administering surveys pre-discussion
III. Administering surveys

DAY TWO

IV. Data analysis

Duration
2 Class Days

PART I

Engineering Design Challenge Introduction

A. Have the students discuss, "What does it mean to make our class and school community more sustainable?

B. In this discussion, talk about both technical aspects (e.g. using green energy as a long term solution, see **Lesson 3**) and social aspects (e.g. making community happier and healthier). They also may include reasons why this is important.

C. Record class ideas because you will return to them in **Part II.**

D. Introduce the design challenge: Explain that the goal is now to make their class and/or school community sustainable. Remind students that they can come up with designs that:

- Innovate something that already exists in the classrooms
- Create something new that contributes positively to the classroom

E. Look at the example of the "Woot Wall" on the slideshow

F. The engineering design must meet the following criteria:

- Renewable energy source
- Make something light up
- Use materials that are readily available and reusable at school

G. Discuss each of the criteria:

1. **Use a renewable source of energy.** Ask students to review what renewable energy sources the class has: hand cranks, solar panels, piezoelectric pads
2. **Make something light up**
3. **Use materials that are readily available at school.** Brainstorm what that means for your class's context. If a student asks if they can bring materials from home, either decide for yourself or open it to the class as a discussion
4. **Use EfSC principles in the design** (see sidebar)
5. **Sustainability** (see sidebar)

EfSC Principles

1. Uses community members' ideas in engineering
2. Helps the community solve their problems through engineering
3. Cares about the environment
4. Designs solutions for now and in the future.

DISCUSSION

Class Sustainability

As a class, discuss, "What sustainability goals do we have as a class community?" Have students brainstorm and record the goals. You could have students write these on sticky notes and place them on a bigger piece of poster paper or have a student record them on a poster. Save this for future conversations.

DESIGN CHALLENGE

PART II

Administering Surveys Pre-discussion

A. Point to the engineering for sustainable communities principles and the engineering design cycle, and remind students that getting community perspectives on their problem is really important.

B. Ask them who they should ask for help in defining problems and why.

C. Explain that they're going to use a survey to share with their school community.

D. Project the survey questions provided for students to read. Discuss each of the questions and what answer choices they would provide in their survey for the problem categories they identified. The survey link is in the slide show and on the QR Code sheets.

PART III

Administering Survey

A. Divide the class into groups that will be working on their design together.

B. Ask for three volunteers to model survey administration (question, asker, respondent, recorder).

C. Have students practice in small groups as they complete the survey themselves. Make sure to assign a talker and recorder. Group members can trade-off on who does what. If you have access to enough iPads and WiFi, have students simply use they Survey Monkey URL. If you do need to print the survey, you will need to stop the lesson here and continue later once the surveys are printed. If not, print off the surveys, and have students record the answers using a pen or pencil.

D. Have students give the survey to community members.

- You can do this by pre-arranging with the office, cafeteria staff and other teachers for students to visit their spaces and give the survey.
- You can have community members come to your classroom.
- You can have your whole class go to another class.
- You can email your survey out for your students.
- You can utilize a combination of these options. Try to get at least 20 responses from three different type of stakeholders.

TIPS

It is a great opportunity for students to administer the survey in person. By doing this, they are able to get recognized for their expertise, explain their work, and receive verbal feedback in addition to electronic responses.

Be creative in other ways to get community members to fill out the survey: Email or text a link to the survey to family members! If you have kids after school, have a couple of volunteers to administer the survey to parents as they pick up.

DESIGN CHALLENGE

PART IV

Data Analysis

Reviewing Data as a Class

A. Project the graphs and collated open-ended response for one stakeholder group (e.g. adults).

B. Have the class review the graphs and results.

- Which problems received votes?
- What were some of the reasons that people gave for why these were problems?

C. Have students discuss these reasons and problems, and decide which problems and reasons are most compelling and why. Have them record their top idea on the Community Survey Analysis handout (5C).

D. Then ask students to look at **question #4** (ideas for solutions). Have them discuss which ideas give them inspiration.

Reviewing data in groups and jigsaw

E. Assign groups to their engineering design groups. These groups should have three students ideally.

F. Have students complete the data analysis sheet together.

G. Discuss as a class the problems that mattered most to the community, what problems the groups want to address and initial brainstormed ideas for solutions.

H. Have students revisit and revise the class list of sustainable community goals.

This sharing positions each student as an expert.

Lesson Notes

Prior to this part of the lesson, print data summaries from Survey Monkey, filtered by stakeholder (e.g., kid, adult, community.)

COMMUNITY SURVEY

Name:

1. Kids Results

What are the top 3 problems kids identified?	What percentage of kids cared about this problem?	Why do you think this is a problem?

2. Adult Results

What are the top 3 problems adults identified?	What percentage of adults cared about this problem?	Why do you think this is a problem?

COMMUNITY SURVEY

Name:

3. Using the data above, what problem do you choose to fix?

4. Why do you care about this problem?

5. List 3 ideas for fixing the problem that use circuits, LED lights and a green energy source.

- Feel free to use the ideas that your class has brainstormed earlier.
- Try glancing at the survey responses for ideas, too.
- Feel free to write or draw and label your answers.

COMMUNITY SURVEY ANALYSIS RUBRIC

Name:

Lesson 5 Objective: Students will define a problem that matters to their school community that they can solve within the constraints of the design challenge.

	i-Engineering Big Ideas	Criteria	Is this present? No Evidence	Evidence Present	Strong Evidence	Feedback
Engineering for Sustainable Community Principles	Uses community members' ideas in engineering	Determined problems that mattered to their community most by using evidence.				
Energy Practices	Defining Problems	Defined a problem that could be addressed with an i-Engineering project.				
		Defined a problem that reflected community and personal concerns.				
	Obtaining, evaluating and communicating information	Analyzed community survey results to determine problems that mattered to their community most				

CUESTIONARIO COMUNITARIO

Nombre:

1. Resultados de los ninõs

¿Cuáles son los tres problemas principales que identificaron los niños?	¿Cuál es el por ciento de niños preocupados por este problema?	¿Por qué crees que esto es un problema?

2. Resultados de los adultos

¿Cuáles son los tres problemas principales que identificaron los adultos?	¿Cuál es el por ciento de adultos preocupados por este problema?	¿Por qué crees que esto es un problema?

CUESTIONARIO COMUNITARIO

Nombre:

3. Usando los datos de arriba, ¿cuál problema solucionarías??

4. ¿Por qué te importa este problema?

5. Enumera tres ideas para solucionar este problema utilizando circuitos, luces LED y una fuente de energía verde.

- Siéntete libre de usar las ideas que se desarrollaron en clase.
- También puedes echar un vistazo a las respuestas del cuestionario para tomar ideas.
- Siéntete libre de escribir o dibujar e identificar tus respuestas.

RÚBRICA DE ANÁLISIS DE LOS RESULTADOS DEL CUESTIONARIO

Nombre:

Objetivo de la leccioń 5: Definir un problema que le importa a su comunidad escolar que se puede solucionar dentro de las limitaciones de un reto de diseño.

i-Grandes ideas de ingeniería		Criterios	¿Esto se encuentra?			Comentarios
			No hay evidencia	Hay evidencia	Hay evidencia sólida	
Principios de ingeniería para una comunidad sostenible	Usa las ideas de ingeniería de los miembros de la comunidad.	Determina los problemas que más le importan a la comunidad usando evidencia.				
Ciencia y prácticasde ingeniería	Definir problemas	Define un problema que se puede attender con un Proyecto de ingeniería.				
		Define un problema que refleja preocupaciones per-sonales y comunitarias.				
	Obtener, evaluar y comunicar información	Analiza los resultados del cuestionario a la comunidad para determiner los prob-lemas que más le importan a la comunidad.				

ENGINEERING for
SUSTAINABLE COMMUNITIES

LESSON 6

What can we design to address the problem that matters most to us and our communities?

Background for Teachers
In this lesson, students will prepare their initial sketch up for their engineering design. It is useful to let students know that their designs will be altered multiple times based on interviews, and test done along the design process to optimize the sketch up. These revisions should be done in the original sketch up by using different colors to note new revisions at each phase.

INITIAL DESIGN

DRIVING QUESTION

What can we design to address the problem that matters most to us and our communities?

Overview

Engineering for sustainable communities relies on iterative decision making that includes perspectives of community stakeholders. This iterative process changes as new social and technological dimensions are (re)defined when collecting ethnographic data and during the analysis process.

However, before design iterations begin, we need to focus on the technological dimensions that are needed to create the design such as power requirements, and circuitry of the design. Social dimensions will drive the next set of design iterations as the design need to meet specific community needs. At the end of this lesson, students should develop an understanding that community feedback is important in the iterative design process.

Lesson Standards

MS-ESS3-3: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment

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 is achieved

Objective

Students will be able to design both the social and technical specifications of initial design ideas using an engineering for sustainable communities approach.

'I Can' Statement

I will sketch up both the social and technical specifications of my engineering design using an engineering for sustainable communities approach.

Materials

- Printouts of survey data
- Poster paper for designs
- Battery
- Lights
- Various electric small appliances
- Apples or 100 g masses

Equipment

- Lamp
- Hand-crank generator
- Solar panel
- Piezoelectric pads

Handouts

6A – Sketch-up Worksheet
6B – Sketch-up Checklist

LESSON SEQUENCE

I. Modeling sketch-ups
II. Solution brainstorm
III. Initial design sketch-ups

Duration

1 Class Day

TIP

For groupings, consider how you can support individual students to have agency. Are there students who tend to dominate conversations and those who do not? How can you shift discourse patterns to support all students in your classroom?

PART I

Modeling Sketch-ups

A. Begin class by explaining that today's goal is to create a sketch-up of the design solution to the problem each group decides to address.

B. Sketch-up A: Model how to choose a problem and practical solution with the "Woot Wall" example. Using an example problem-space chart about class morale. Look at the problem-space chart and ask out loud, "What problem seems to matter most to my community? Which problem do I want to solve most? Why?" Answer those questions for yourself.

Example: *"I think I want to address the problem of low class morale. It seems to matter to both students and teachers. It matters a lot to me because my class is important to me, and I want everyone to feel part of a happy community. Also, both adults and kids think this is a problem."*

Emphasize that the problem that the groups share needs to have a technical solution not just a social solution.

C. Complete a Sketch-up Worksheet (6A) while talking out your answers with your students:

I am going to address the problem of low class morale, and my reasons are:

1. *I know that students do lots of great things that do not get noticed all the time.*
2. *60% of students said class morale was a problem.*
3. *50% of adults in the school said class morale was a problem.*

This is how I want to address this solution:

We are going to create a light up bulletin board that uses a hand-crank generator. We will put up students' accomplishments in the middles of the bulletin board. When members of our class see students do really great things, we will light up the board using the hand crank. We will call it a "Woot Wall."

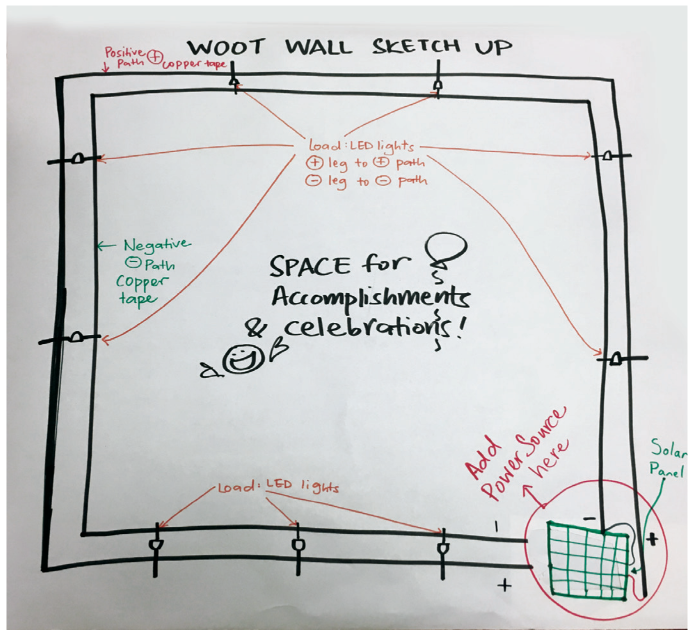
My idea is practical because it:

- Uses an available renewable energy source: **hand-crank generator**
- Uses these available materials: **copper tape, 16 LED lights, bulletin board, hand-crank generator, duct tape**
- Does it make something light up: **yes**

INITIAL DESIGN

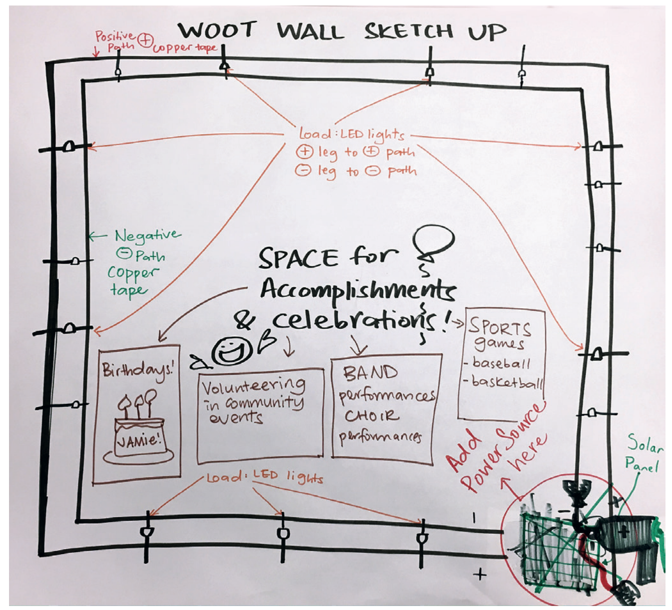
Examples of how the Woot Wall sketch-up was optimized:

PHASE I



This is the level of detail you are looking for in this lesson.

PHASE II



Based on interviews, students will improve their design before they build. This helps them to create working prototypes and understand community desires.

D. Sketch-up B (the actual drawing). Explain to students that after they complete sketch-up A, they will share it with the teacher then draw their sketch up. First, you will sketch up the design. Model the initial design sketch-up with the Woot Wall:

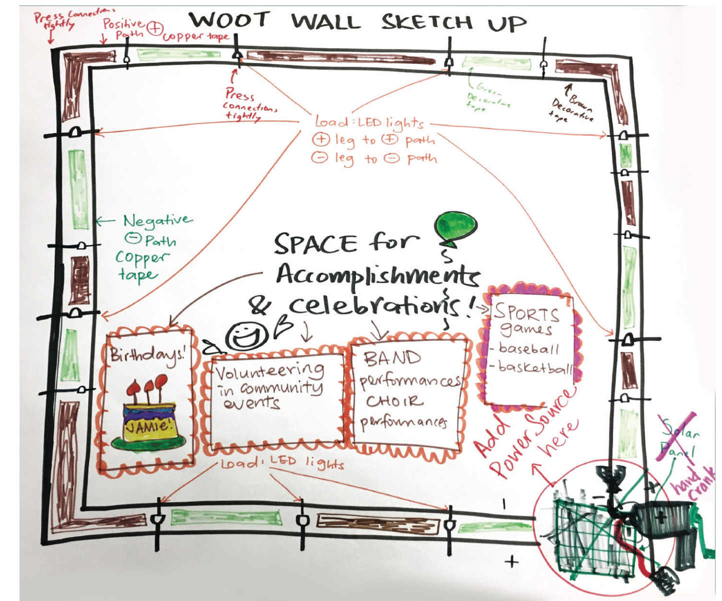
1. Hang up the sketch and explain the different parts of the sketch-up.
2. The sketch-up shows how the design works and the materials needed.
3. Sketch and label your design. Make sure to point out the different labels including the energy source, pathway, load, and direction of electricity flow.
4. Complete the technical specifications on the Sketch-up Worksheet (6A). Ask students for input in answering each question.
5. Complete the social specifications on the Sketch-up Worksheet (6A). Ask students for input in answering each question.
6. Check off each part of the Sketch-up Checklist (6B) as you go. This checklist will help the groups work independently and move at their own pace.

Lesson Notes

We have budgeted one class period for this lesson with the understanding that this activity will take around fifteen minutes.

INITIAL DESIGN

PHASE III



Final revisions are made based on tests designed by the students. Notice there have been changes to the initial design and more details have been added.

E. Materials: Remind your students that they will need to use a green energy source (hand-crank generator, piezoelectric pads or solar panels) to light up lights. They can also use other supplies available in the classroom like cardboard, tape, various craft supplies, parts of the actual classroom (bulletin boards, walls, etc.) that you are comfortable with and so forth.

Invite each group to visit a table with supplies laid out for them to explore. Have the technical equipment and materials to test out. This will help them expand what types of solutions they may brainstorm and also help them stay within the constraints of the unit.

INITIAL DESIGN

PART II

Solution Brainstorm

A. Have small groups decide what problem they want to solve. Have groups write their problem down and include three pieces of evidence that it is a problem. See Sketch-up Worksheet (6A).

B. As a whole class, discuss what problems the class wants to solve. Record the different problems. Discuss how their goals align with the class' sustainability goals that they listed during **Lesson 5** before administering the surveys. Revise the poster to reflect the goals.

C. Have students brainstorm solutions in their group for an engineering design that could solve the problem they defined using the materials available.

D. Model with the Woot Wall how to analyze both the social and technical specifications of the Woot Wall design in connection to the engineering for sustainable communities principles. See Sketch-up Worksheet (6A).

E. Have groups analyze both the social and technical specifications of their design in connection to the engineering for sustainable communities principles. See Sketch-up Worksheet (6A).

PART III

Initial Design Sketch-Ups

Small groups complete their initial design sketch-up by:

1. Sketching and labeling their designs in groups on the large poster papers. Make sure to point out the different labels including the energy source, complete circuit, and direction of electricity flow.
2. Make sure that students put the dimensions on the sketch so that they are clear about the size of their design and related material needs.
3. Complete the Sketch-up Worksheet (6A).
4. Have students complete **Steps 1–7** on their Sketch-up Checklist (6B), which they should attach to their sketch up. They will complete the other steps in **Lesson 7.**

SKETCH-UP WORKSHEET

Name: ______________________

Group Members: ______________________ ______________________
______________________ ______________________

Complete and staple this to your sketch-up.

We are going to address the problems of ______________________ and these are our reasons:

1. ______________________
2. ______________________
3. ______________________

This is how we want to solve it:

Our idea is practical becasue:

Who will use it? ______________________

How? ______________________

It uses this available renewable energy source: ______________________

It uses these available materials:

Does it make something light up? ____________

Share this work with your teacher and get their signature: ______________________

SKETCH-UP CHECKLIST

Name: ______________________

Group Members: ______________________ ______________________
______________________ ______________________

Task	Check (✔) when completed	Date Completed
1. We agreed on a problem to address.		
2. We came up with an idea for a solution.		
3. We checked our idea with our teacher.		
4. We drew our design.		
5. We labeled the energy source ____ , the pathway _____ , direction of electricity flow ____ , and lights ____.		
6. We listed all of the materials we need.		
7. We checked our design plan with a teacher.		
8. Wrote four questions to be answered by the community experts.		
9. Made changes to the sketch-up based on community feedback.		
10. We checked our revised design plan with a teacher.		
11. Completed prototype plan.		

TIPS FOR GROUP SUCCESS

- **Groups are Gold** Stay with your group, and only leave them with the purpose of helping your group.
- **Two then me** Ask for help from two students before you ask the teacher for help.
- **Everyone matters** Each group member contributes and is cared for in their group.

HOJA DE TRABAJO DE SKETCH-UP

Nombre: ______________________

Miembros del grupo: ______________________ ______________________
______________________ ______________________

Complete y engrape esto en su sketch-up.

Vamos a abordar los problemas de ______________________ por las siguientes razones:

1. ______________________
2. ______________________
3. ______________________

Queremos resolverlo así:

Nuestra idea es praćtica porque:

¿Quién lo usará? ______________________

¿Cómo? ______________________

Usa una fuente de energía removable disponible: ______________________

Usa los siguientes materiales:

¿Hace que otra cosa se encienda? ______________

Comparte este trabajo con tu maestro y obtén su firma: ______________________

LISTA DE COTEJO DEL DISEÑO

Nombre:

Miembros del grupo: ______________________ ______________________
______________________ ______________________

Tarea	Haz una marca de cotejo (✔) al completar	Fecha completada
1. Acordamos abordar un problema.		
2. Nos inventamos una idea para solucionarlo.		
3. Corroboramos nuestra idea con el maestro.		
4. Dibujamos nuestro diseño.		
5. Identificamos la fuente de energía ______ , el conductor ______ , la dirección del flujo de electricidad ______ y las luces ______ .		
6. Hicimos una lista de todos los materiales que necesitaríamos.		
7. Revisamos nuestro plan de diseño con un maestro.		
8. Escribimos cuatro preguntas para que las respondieran los expertos de la comunidad.		
9. Hicimos cambios al diseño basados en los comentarios de la comunidad.		
10. Revisamos nuestro plan de diseño modificado con un maestro.		
11. Completeamos el plan del prototipo.		

LOS SIGUIENTES CONSEJOS PARA TENER EX́ITO COMO GRUPO

- **Los grupos son un tesoro** Quédate con tu grupo y no te quites, al menos que sea para ayudar al grupo.
- **Dos, despueś yo** Pide ayuda de otros dos estudiantes antes de pedirle ayuda al maestro.
- **Todo el mundo es importante** Cada miembro del grupo contribuye y es importante para el grupo.

ENGINEERING for SUSTAINABLE COMMUNITIES

LESSON 7

How can we use community feedback to optimize our design?

Background for Teachers

Multiple solutions to an engineering design problem are always possible because there is more than one way to meet the criteria and satisfy the constraints. But the aim of engineering is not simply to design a solution to a problem but to design the best solution. Determining what constitutes "best," however, requires value judgments, given that one person's view of the optimal solution may differ from another's. Optimization often requires making trade-offs among competing criteria.

DESIGN OPTIMIZATION WITH COMMUNITY FEEDBACK

DRIVING QUESTION

How can we use community feedback to optimize our design?

Overview

In this lesson, student will incorporate feedback from community members to improve their designs before they prototype it. Engineering design solutions for sustainable communities relies on iterative decision-making that includes problems and perspectives of community stakeholders.

This iterative process changes as new social and technological dimensions are (re)defined when collecting ethnographic data and during the analysis process. In this lesson, student will incorporate feedback from community members to improve their designs before they prototype it.

Lesson Standards

MS-EES3-3: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment

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-ETS1-4: Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design is achieved

Additional Background on Trade-offs

In design optimization, as one criterion (such as lighter weight) is enhanced, another (such as unit cost) might be sacrificed (i.e., cost may be increased due to the higher cost of lightweight materials). In effect, one criterion is devalued or traded off for another that is deemed more important. When multiple possible design options are under consideration, with each optimized for different criteria, engineers may use a trade-off matrix to compare the overall advantages and disadvantages of the different proposed solutions (NGSS).

Objective

Students will be able to optimize both the social and technical aspects of their design by incorporating more community feedback.

'I Can' Statement

I can optimize my design using community feedback.

Handouts

7A – Feedback Interview

Equipment

Devices to record interview such as iPads, laptops, or cell phones

KEY TERMS

Design Optimization Involves making trade-offs among competing criteria to meet your desiredneeds (technical and social).

Trade-offs One important aspect of what engineers do every day is to analyze and improve efficiency. By making changes to technology and human processes, engineers are always trying to think of new ways to save us time, energy, materials and costs. Engineers also look for ways to save people time in their daily lives by making trade-offs" A trade-off occurs when we sacrifice one thing to gain something else that we value more. Trade-off decisions are made for social, environmental and sometimes economic benefits.

LESSON SEQUENCE

I. Create interview protocol
II. Interview
III. Optimize design
IV. Class presentations and feedback

PART I

Create Interview Protocol

A. Point to the EfSC principles and the engineering design cycle. Ask: *"At this point, what should we do before we build our design?"* Students should get to the point where they talk about getting community feedback on their design as important.

- Ask: "Who should we get feedback from to optimize our design? Brainstorm a list with your students. **Examples could include classmates, teachers, staff members, parents, engineers and so forth.**
- Tell your students that you have arranged for them to be able to interview some of those community members, but first they need to write questions to ask.

B. Review the difference between technical and social aspects. You can ask them to share examples of each. For example: *"Do you think the Woot Wall's circuit will allow it to light up?"* is a technical specification question and *"Who would use this engineering design?"* is a social specification question. Or you can share examples of types of questions that you would want to ask in an interview and have students stand up for social or sit down for technical specifications or simply say out loud: "technical" or "social."

Then have students share what a technical specification is in their own words and what a social specification is in their own words.

C. Have your students write four questions that they would like to ask their community members.

- Two questions must be social aspect questions
- Two questions must be technical aspect questions.

D. Have students write down who will ask each question. **This will help all youth have a role in the interview and get started in the interview.**

Lesson Notes

Students will change their designs based on feedback. This is important to help students create designs that work.

Emphasize that the designs do not have to be beautiful, but they do need to be detailed.

This means that they should include any or all the changes they think are necessary in the same sketch-up.

TIPS

Conducting interviews provides opportunities for students to be recognized by a wide range of others.

Plan ahead for this, and invite people to join our class virtually if they cannot come in person.

Bringing together technical and social aspects provides different opportunities for students to connect with the project and to show different forms of expertise.

DESIGN OPTIMIZATION WITH COMMUNITY FEEDBACK

PART II

Interview

A. Interview Model: Model how to have an interview using the Woot Wall as an example. The teacher can be the student, and a student can be the person who is being interviewed.

B. Have students interview two different community members plus at least one classmate. Each interview should take about five minutes.

The community members can be a selection of the people your students' previously brainstormed. If you are pressed for time and access to community members students could interview students from another group in your classroom, or family and friends at home as homework. **Students should bring their sketches to the interview and explain how they work.**

- Have students ask their questions. Each group member should ask one question.
- At the end of each interview, students should stop and take 2–3 minutes to write down everything they have learned under each question.

PART III

Optimize Design

A. Incorporating interview feedback: Ask students to review their interview data in groups. Ask them to identify what feedback seems most useful.

B. Have them add these ideas to their sketch-up design using different colors and making sure to label these changes.

C. Have them note the added steps they took on their Sketch-up Checklist (6B).

PART IV

Class Presentations and Feedback for Further Optimization

A. Peer review: Have each group present their sketch-up to the class, highlighting the following:

- What problem does your design address?
- How does your design work?
- Who and how will it be used?
- What changes did you make based on community feedback? Why?
- What is one potential problem you are worried about in getting the design to work?

B. We suggest that each group have about **2 minutes** to address these questions plus **2 minutes** for class feedback **(4 minutes per group)**. We also recommend that groups present when they are ready instead of waiting for everyone to present at the same time.

C. As groups are presenting, the teacher can support students in making their designs as practical as possible.

D. As a whole class, revisit your sustainable community concerns poster and discuss how the projects are or are not addressing the sustainability concerns.

Sample Woot Wall Interview

Social Aspect Questions:

- Do you think this design will help class morale?
- Who can use this woot wall and when/why?

Technical Aspect Questions

- How long would you want the lights to stay on?
- Would you prefer the lights to be powered by solar panels or a hand-crank generator?

FEEDBACK INTERVIEW

Name: ____________________

Group Members: ____________________ ____________________ ____________________ ____________________

1. Name of engineering design:

2. Problem it is supposed to solve:

INTERVIEW QUESTIONS

3. Technical aspects questions

A.

Who will ask this question? ____________________

B.

Who will ask this question? ____________________

4. Social aspects questions

A.

Who will ask this question? ____________________

B.

Who will ask this question? ____________________

Notes

Write what you learned from the interviews here.

ENTREVISTA DE RETROALIMENTACIÓN

Nombre:

Miembros del grupo: ____________________ ____________________
____________________ ____________________

1 . Tiťulo del disenõ de ingenieriá:

2. Problema que se suponiá que solucionara:

PREGUNTAS DE LA ENTREVISTA

3. Preguntas sobre los aspectos teć nicos

A.

¿Quién hará esta pregunta? ____________________

B.

¿Quién hará esta pregunta? ____________________

4. Preguntas sobre aspectos sociales

A.

¿Quién hará esta pregunta? ____________________

B.

¿Quién hará esta pregunta? ____________________

Anotaciones

Escribe lo que aprendiste de estas entrevistas aquí.

ENGINEERING for
SUSTAINABLE COMMUNITIES

LESSON 8

Can we prototype our design?

Background for Teachers

A prototype is a representation of the final product. Prototypes vary in how realistic they are. For example, engineers build smaller prototypes of skyscrapers that can fit in an office while others create working appliance prototypes to test them before designing full-scale manufacturing processes. They should make them as functional as possible. This will vary from group to group. If students' designs stayed within the constraints of using only hand- cranks, solar panels or piezoelectric pads to light up something or make noises, students should be able to work in groups independently.

PROTOTYPING DESIGNS

DRIVING QUESTION

Can we prototype our design?

Overview

In this lesson, students will first explore what steps they have already taken in the engineering design cycle. Then, the class will review norms for building and working together as groups. Finally, they will build their prototypes.

Lesson Standards

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-ETS1-4: Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design is achieved

These pictures show students practicing the "hands on, eyes on" approach. "Hands on, eyes on" is a practice that expects youth makers to maintain both, hands and eyes on the task they are doing while working on their prototypes. In addition to promote overall classroom safety, this practice promotes students' agency.

Objective

Students will prototype their designs while utilizing feedback from others.

'I Can' Statement

I can prototype my designs utilizing feedback from others and my STEM expertise.

Materials

- Hand crank
- Piezoelectric pads
- Small solar panels
- Copper tape
- Wires
- Simple motors
- Various LED lights
- Cardstock
- Cardboard
- Scotch tape
- Masking tape
- Electrical tape
- Washi tape
- Duct tape
- Glue sticks
- Markers
- Craft sticks
- Pipe cleaners

Equipment

- Wire cutters
- Scissors
- Voltmeter

LESSON SEQUENCE

I. Group discussion
II. Creating prototype plan
III. Prototyping/building
IV. User guide

PART I

Group Discussion

A. As a class, look at the engineering design cycle. Have the students review the steps that they have taken so far and remind them that they will have to go back through the cycle as they experience challenges of prototyping.

B. Review material constraints with your class:

- Each group gets one energy source.
- Each group gets the materials listed on their material list.
- Put all materials in each group's work area.
- If they need more, they must discuss it with their teacher.
- While they can use cardboard, it is better for the students to find a sturdier source on which to build their circuit. For example, they can put the copper tape directly on the wall or bulletin board instead of putting it on cardboard first.

C. Review your class' norms for project work. Here are some tips you may find handy:

- **Hands on, eyes on** If you are ever using materials and equipment your eyes are concentrated on those not others.
- **Groups are Gold** Stay with your group, and only leave them with the purpose of helping your group.
- **Three, then me** Ask for help from three students before you ask the teacher.
- **Everyone matters!** Each group member contributes and is cared for in their group.

Duration

2–3 Class Days

Handouts

8A – Sample Prototype Plan
8B – Prototype Plan
8C – Engineering Design User Guide

TIP

By actually building their own ideas, students are actually engineering. They are making their own engineering design.

PROTOTYPING DESIGNS

PART II

Creating Prototype Plan

A. As a class, go over the example of the prototype plan (8A).

B. Have each group fill in their own prototype plan (8B).

C. Once they are completed, have students share their plan with you. Have them add any critical steps missing. Once you think their plan will lead them to success, have them get their materials and move onto the prototyping step.

PART III

Prototyping/Building

A. Have students prototype their work in groups following your class' project norms.

B. As students complete each step of their design, they should check it off on their design rubric (8B).

C. Once the design is working, students should move on to the early finisher steps listed below. **This will help ensure the designs do not break from overuse.**

PART IV

User Guide

A. Have groups create a user guide (8C) to be displayed with the engineering design. The user guide should include who and how the engineering design should be used.

B. User guide community feedback: have students share their user guide with another group of students, the teacher, and someone representing whoever else will be using the engineering design. Have the students get feedback and revise their user guide.

C. As a class community, use the engineering design according to the user guide.

D. During this stage of the unit, groups will work at different speeds. Be clear with students about how much time they will have for prototyping. 2–3 class periods should be sufficient. If groups seem like they will not finish in time, provide alternatives times for them to finish if possible.

If any students finish early, they can:

- Add more outputs to their design and add them to the prototype. For example, encourage students to add a noisemaker to their Woot Wall design.
- Have students become helpers for other groups.

TIPS

Students are positioned with more agency by creating their own prototype plan. They are creating a way for themselves to find engineering success and strategies to follow when they face challenges.

By rotating who is the lead student in charge of each step, every student will be positioned as an expert.

Have each group share their materials in a labeled box. This helps for easy clean up and quick starts for prototyping

SAMPLE PROTOTYPE PLAN

Group Members: ____________

Prototype Name: ____________

EXAMPLE

A Woot Wall A thick poster board with a LED-light border. In the center of the board there is space to put students' accomplishments on the board with sticky notes. The border is a parallel circuit with five lights. It is powered by a hand-crank generator. It will honor students' accomplishments.

Big Steps	What do we need to consider during this step?	Challenges we are facing and ideas for addressing them:
1. Decorate the board's background.	The background needs to be a good surface to attach copper tape. It should look neat, and students should like it.	The cardboard is bumpy, which makes it hard to attach the copper tape. So we will first create a border of duct tape and put the circuit on top of that.
2. Build circuit onto the border of the board.	The lights should be positioned to bring attention to the board. We should limit resistance in the circuit by pressing the copper tape down tightly and putting tape on the top and bottom of LED leads.	
3. Attach the hand-crank generator.	The hand crank needs a place to sit when it is not being used, so it doesn't fall off of the Woot Wall.	The hand crank is heavy, so we placed the Woot Wall on the top of a bookshelf so everyone could see it still, but the hand crank had a solid place to sit.
4. Post students' accomplishments.	We want to make sure a wide range of students' accomplishments are celebrated and new accomplishments are recorded.	New accomplishments are not being written down. We talked to our teacher, and during bell work time students can get sticky notes to write down their peers accomplishments.

PROTOTYPE PLAN

Group Members: ______________________

Prototype Name: ______________________

Big Steps	What do we need to consider during this step?	Challenges we are facing and ideas for addressing them:

ENGINEERING DESIGN USER GUIDE

Group Members: ______________________ ______________________
______________________ ______________________

Prototype Name: ______________________

1. Who will use this design?

2. When will it be used?

3. This is how to use our engineering design:

Write directions here.

CREAR UN PROTOTIPO

Miembros del grupo: ______________________
____
____
____

Nombre del prototipo: ______________________

EJEMPLO
Una caja de cartón que, al levantar la tapa, hará que un hipopótamo de juguete gire encima de un motor pequeño. Es alimentado por un panel solar. Ayudará a la autoestima de la clase.

Grandes pasos	¿En qué necesitamos pensar para hacer esto paso?	Retos que nos enfrentamos e ideas para afrontarlos:
1. Caja de construcción.	La caja debe ser lo suficientemente profunda para aguantar la caja de sonido. No queremos que sea tan grande que no quepa sobre el escritorio de un estudiante.	El cartón es demasiado frágil para aguantar el hipopótamo. Usamos el cartón de una caja más gruesa.
2. Construye elcircuito en la caja con un motor simple.	El circuito debería tener las dimensiones correctas para que quepa correctamente en la caja. (¿Dónde queremos colocar la caja? Al fondo de la caja, al lado de la caja, la parte superior de la caja.)	
3. Fija el hipopótamo al motor simple.	Usaremos la pega caliente para fijar el hipopótamo. Esto es para asegurarlo a la caja.	El circuito se encontraba en la caja de una manera que no fijaba bien el hipopótamo. Movimos el circuito al fondo de la caja para que cupiera el hipopótamo.
4. Posiciona el panel solar para que le dé la luz.	Necesitamos colocar el panel solar en la parte superior de la caja para que le dé la luz.	Tuvimos que rediseñar el circuito para que los cables se conectaran con el panel solar cuando estuviera fuera de la caja.

CREAR UN PROTOTIPO

Miembros del grupo: ____________________

Nombre del prototipo: ____________________

Grandes pasos	¿En qué necesitamos pensar para hacer esto paso?	Retos que nos enfrentamos e ideas para afrontarlos:

GUÍA DEL USUARIO DE DISEÑO DE INGENIERÍA

Miembros del grupo: ____________________ ____________________
____________________ ____________________

Nombre del prototipo: ____________________

1. ¿Quién usará este diseño?

2. ¿Cuándo se utilizará?

3. Así es como se utiliza nuestro diseño de ingeniería:

Escriba las instrucciones aquí.

ENGINEERING for
SUSTAINABLE COMMUNITIES

LESSON 9

What data do I need to improve my design?

Background for Teachers

In this lesson, students will conduct technical tests on their designs. They do this first to optimize their design before they get social specification feedback. Students then get social feedback on their design. Students can do informal interviews with individuals in your building. At this point, students will be working predominantly on their own pace.

REFINING YOUR PROTOTYPE

DRIVING QUESTION

What data do I need to improve my design?

Overview

In this lesson, student will incorporate feedback from community members to improve their designs before they prototype it. Engineering design solutions for sustainable communities relies on iterative decision-making that includes problems and perspectives of community stakeholders.

This iterative process changes as new social and technological dimensions are (re)defined when collecting ethnographic data and during the analysis process. In this lesson, student will incorporate feedback from community members to improve their designs before they prototype.

Lesson Standards

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 so an optimal design can be achieved

Objective

Students will improve their engineering designs using technical tests and community feedback.

'I Can' Statement

I can improve my engineering design using technical tests and community feedback.

Materials

- All prototyping supplies from **Lesson 8**
- Prototypes of engineering designs

Handouts

9A – Testing My Design, part I
9B – Testing My Design, part II

Equipment

- All prototyping equipment from **Lesson 8**
- Audio recording devices

LESSON SEQUENCE

I. Design and complete three technical tests
II. Optimize design based on test results

PART I

Design and Complete Three Technical Tests

A. Introduce today's objective to optimize the design through technical tests.

B. In your ideal engineering dream, describe in one or two sentences exactly how your prototype works. You need to include something about a) your power source, b) your load, c) the function.

PROMPT:

My **[prototype name]** uses **[power source]** to power **[name load]** to **[do what?]**.

SAMPLE SENTENCE:

My **Woot Wall** uses a **hand crank** to power **12 LED lights** to **celebrate students' accomplishments.**

C. As a group, list all of the ways you already improved your design. (e.g. We switched from a series to a parallel circuit. We colored the lights.)

D. How will you test your design to get ideas for how to improve it? Record your ideas on the Testing My Design handouts (9A, 9B).

Technical questions

[if my design is working] Can I see all of the lights from the back of the classroom?

[if my design is **not yet** working] Can I figure out why it is not working?

Sustainability question

How can I improve my design so that it can last for the rest of the school year?

Social question

Do people like it?

E. Design tests for each question. See handouts (9A, 9B). Include: *How will the test be conducted? What data will be collected? How will your test be fair?*

F. Review class norms for projects

G. Have groups design and test three tests

H. Have students record their results on the Testing My Design handouts (9A, 9B).

Duration

2 Class Periods

TIP

Students have agency in designing the types of tests they think are important.

You are recognizing students' expertise for what they think matters.

REFINING YOUR PROTOTYPE

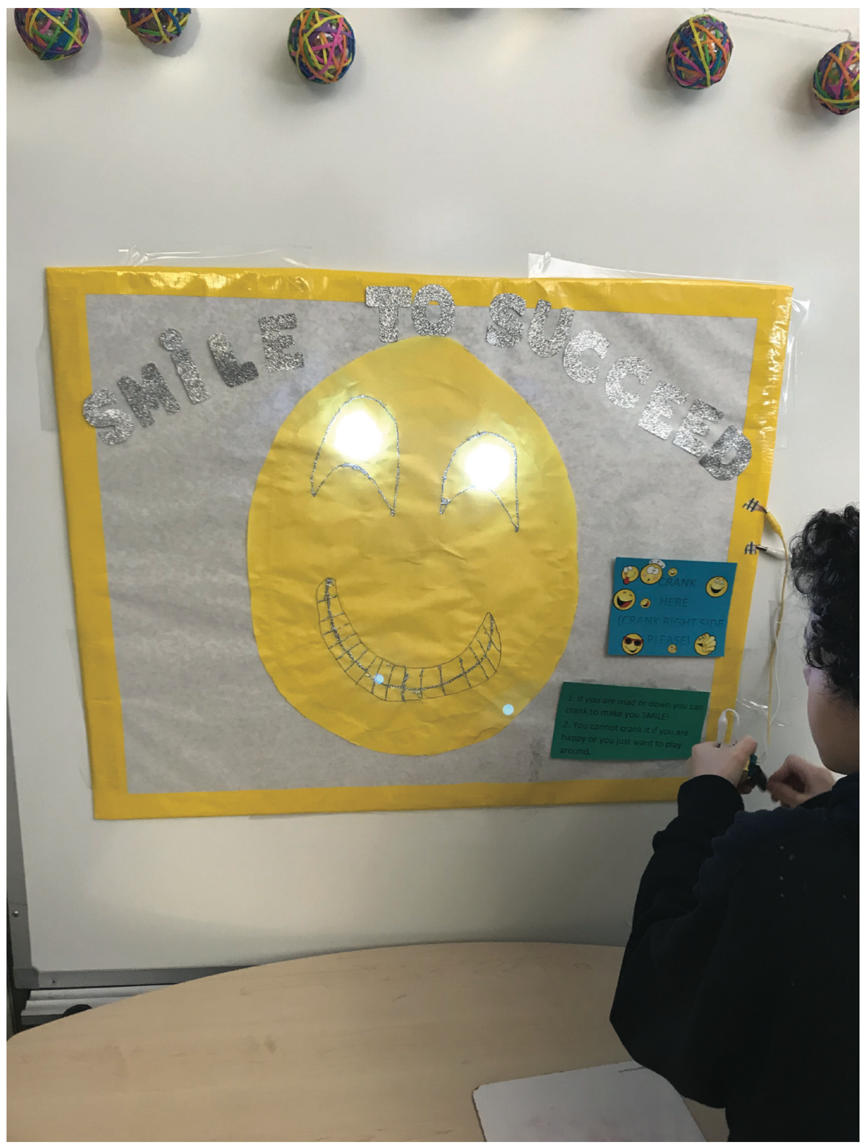
PART II

Optimize Design Based on Results

A. Have students draw the changes they are going to make on their original sketch-up based on the technical tests.

B. Have students make the changes on their actual prototype.

C. As a class, have groups share what changes the groups made to improve their prototypes.



Students conduct technical tests on their designs. They do this first to optimize their design before they get social specification feedback.

TIP

By revising their designs, students are adding sophistication to their design and engaging in authentic engineering work.

TESTING MY DESIGN

Name: ____________________

Group name: ____________________

How does your design work?

Our [prototype name] uses [power source] to power [name load] to [do what?].

Our prototype ____________________ uses ____________________

to ____________________

____

____

We have already improved our design in these ways:

Technical Changes	Social Changes

Make sure you draw all those changes on your sketch-up.

Technical Test

Test:	Results

TESTING MY DESIGN

Conduct each test three times to ensure you have a fair test.

Sustainability Test

Test:	Results

Social Test

Test:	Results

What did I learn about these tests of my design?

Draw and list the changes you will make to your design on your sketch-up

PONER SU PROTOTIPO A PRUEBA

Nombre:

Nombre del grupo: ____________________

¿Cómo funciona su trabajo de diseño?

Nuestro **[nombre de prototipo]** usa **[la fuente de energía]** para encender las luces para que **[¿hacer qué?]**.

Nuestro prototipo ____________________ usa ____________________

para ____________________

____

____

Mejoramos nuestro disenõ de las siguientes maneras:

Cambios técnicos:	Cambios sociales:

Asegúrense que dibujen todos los cambios

Prueba Técnica

Prueba:	Resultados

PONER SU PROTOTIPO A PRUEBA

Lleven a cabo cada prueba tres veces para asegurarse que los resultados son constantes.

Prueba de Sostenibilidad

Prueba:	Resultados

Prueba Social

Prueba:	Resultados

¿Qué aprendí de las pruebas acerca de mi diseño?

Dibujen y hagan una lista de los cambios que harán a su diseño.

ENGINEERING for
SUSTAINABLE COMMUNITIES

LESSON 10

How can I share my engineering design with my community?

Background for Teachers

Sharing the engineering designs with the community is a great way to end this unit for multiple reasons. It connects directly to engineering for sustainable communities because the designs are for people in students' lives. Also, multiple community members perspectives mattered in students' designs. Finally, it is a great opportunity for students to be recognized for their accomplishments.

SHARING ENGINEERING DESIGNS

DRIVING QUESTION

What do I want others to know about my engineering design for sustainable communities?

Overview

In this lesson, youth will create engineering cards, and videos if time allows to share how their engineering design works, and how the design makes their community more sustainable.

This lesson culminates with an opportunity for the youth to share their engineering design work with the larger community.

Lesson Standards

MS-ETS1-2: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. Addresses the practice of obtaining, evaluating and communicating information.

To celebrate students' work, host a showcase. Have students explain their design to their classmates and try out each others' designs. Have students also share their designs with members of the community. It can be powerful if people who provided feedback during earlier stages of the design see how the students adjusted their work.

Objective

Students will explain to their community how their engineering designs works and how it supports sustainability.

'I Can' Statement

I will explain to my community how their engineering designs works and how it supports sustainability.

Materials

Community engineering cards

Equipment

Computers or iPads

Handouts

10A – Script for Showcase
10B – i-Engineering Postcard Rubric

LESSON SEQUENCE

I. Creating youth engineering cards
II. Making videos
III. Community showcase

PART I

Creating Youth Engineering Cards:

A. Re-visit the community engineering cards that your class has utilized earlier in this unit: the Light-up Umbrella, the Woot Wall and the Light-up Football. Say: "Now that you have engineered for sustainable communities, it is time for you to create your own community engineering card."

Have students create their own youth engineering cards using the provided templates on the slide show. This can happen in groups or as individuals. As the students are creating these cards, walk around and prompt them to include as much information as possible. Ideally, the whole class is doing this at the same time. Before the students submit their information, they should have a classmate read it, and have them provide feedback about what else could be included on their card. **This provides an opportunity for the students to both be positioned as experts and will help the students provide a thorough explanation of what they did and why.**

B. Print extra cards for students to exchange and share with community members that matter to them. Ideally, you should print these cards before the showcase so they can share them with others.

PART II

Making Videos

A. If there is extra time or you have early finishers, invite students to create videos about their prototype. The movies should include:

- The technical and social aspects of the design
- Why they made it
- How it works

Duration

1–2 Class Days

TIPS

Students may engage in STEM identity work through the sharing of their inventions with others.

Recognition for your talents, skills, potential, and abilities in an area is key to developing STEM identities.

ShARING ENGINEERING DESIGNS

PART III

Community Showcase

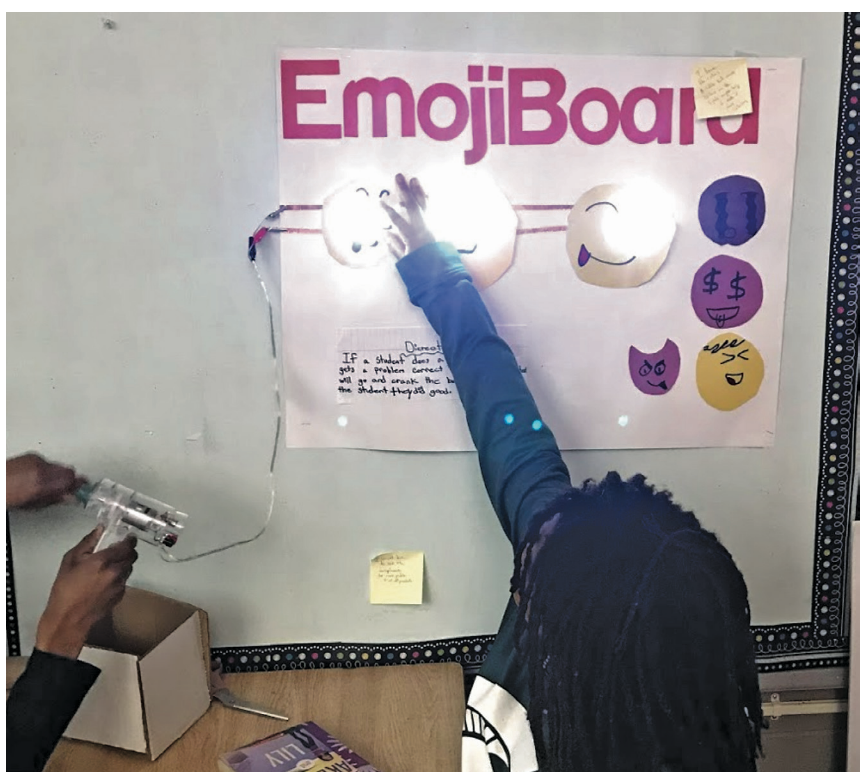
A. Make a plan for sharing your students' engineering design. Here are some ideas you can utilize:

- Invite school staff members, other classes and family members to see their work. Ask visitors to ask students: why they made it, how it works and what changes they made to their design over time
- Email/text loved ones, videos of project
- Display in prominent place in school
- Have students host show and tells for younger students' classes

It can be useful to ask students how they want to share their work. This can allow them to connect the showcase more to engineering for sustainable communities.

B. Have the students complete the Script for Showcase template (10A) to explain:

- Who they are
- What they made
- Why they made it
- How it works



TIP

Additionally, by offering multiple ways for students to share their work, they are able to draw upon other expertise they hold. This success may lead to future identity work for the student in STEM.

SCRIPT FOR SHOWCASE

Name: ____________________

Hello! We are: ____________________

We made the: ____________________

We made it to solve this problem:

____
____
____
____

We know this is a problem because:

____
____
____
____

This is how it works and how we will use it:

____
____
____
____

Do you want to try it? *(Write out any other information that you want to share.)*

____
____
____
____

i-ENGINEERING POSTCARD RUBRIC

Name:

i-Engineering Big Ideas		Postcard Text or Photos	Are these present?
Engineering for Sustainable Community Principles	Uses community members' ideas in engineering	**Describes how design was based on community survey data and how the design incorporated community and expert feedback in iterative changes** (e.g. Community survey data showed we wanted to make learning more fun and we used a parallel circuit instead of a series circuit because of expert feedback)	
	Includes both social and technical aspects of design	**Describes seeking a balance of technical and social aspects of the project, as well as trade-offs, which are a part of the EfSC engineering design process** (e.g. We wanted five color lights in a circle to make it pleasing to look at, but we only had room for a small parallel circuit for four lights)	
	Sustainable over time	**Describes how the engineering process and product will benefit the community now and in the future** (e.g. Knowing students want to have more fun in class from the survey encourages the teacher to use the light-up Happy Box; The Happy Box will stay lit up as long as there is light from the window with solar panels)	
	Reduces negative environmental impacts	**Describes how the project minimizes the negative environmental impacts** (e.g. Our project, made with solar panels to produce renewable electricity, is not emitting CO_2 because we do not use electricity from the wall socket which is often made from burning coal)	
Engineering Practices	Engineering Solutions	**Describes the process of engineering a solution to the problem** (e.g. We built a series circuit, but it didn't work. We tried a parallel one and it worked.)	
Energy Content Knowledge	Types of Energy	**Describes the process of deciding which source of energy to be used** (e.g. This will sit in the window sill where the sun shines in, so we decided to use renewable energy from solar panels)	
	Energy Flow	**Describes the process to design a working circuit** (e.g. We drew a series circuit, but it did not work when we tested it, so we changed to a parallel circuit and then it worked)	
	Energy Transformation	**Explains how energy was transferred in the circuit** (e.g. When we used the hand crank at one end of the circuit, it made the handle of the hand crank we connected at the other end of the circuit move around. Kinetic energy became electric energy and then became kinetic energy.)	
Identity	Introductions	**Describes group members, their interests, experiences, and general location**	

Note: Written work from activity sheets in **Lessons 1–10** can be used in text on the postcards.

GUION PARA LA EXHIBICIÓN

Nombre:

¡Hola! Somos: ______________________________

Creamos el: ______________________________

Lo hicimos para solucionar el problema de:

____

____

____

____

Sabemos que esto es un problema porque:

____

____

____

____

Funciona así:

____

____

____

____

¿Lo quieres probar? *(Escribe cualquier información que quieras compartir.)*

____

____

____

____

I-RÚBRICA PARA POSTAL DE INGENIERÍA

Nombre:

I-Grandes ideas de ingenieriá		Texto o foto de la postal	¿Esto se encuentra?
Principios de ingenieriá para una comunidad sostenible	Usa las ideas de ingeniería de los miembros de la comunidad	**Describe cómo el diseño se basó en los datos del cuestionario a la comunidad y cómo el diseño incorporó los comentarios y las sugerencias de la comunidad y los expertos en cambios iterativos** (Ej. Los datos del cuestionario a la comunidad demostraron que queríamos hacer que el aprendizaje fuera más divertido y Usamos un circuito en paralelo en vez de un circuito en serie siguiendo las recomendaciones de los expertos.)	
	Incluye tanto los aspectos sociales como técnicos del diseño	**Describe la experiencia de buscar el balance entre los aspectos técnicos y sociales del proyecto y las limitaciones, que son parte del proceso de diseño de ingeniería para comunidades sostenibles** (Ej. Queríamos cinco luces de colores en un círculo para que fuera más agradable para la vista, pero solo teníamos espacio para un circuito en paralelo pequeño para cuatro luces.)	
	Sostenibilidad con el tiempo	**Describe cómo el proceso de ingeniería y el producto beneficiarían a la comunidad ahora y en el futuro** (Ej. Sabiendo que los estudiantes quieren clases más divertidas según el cuestionario, se alienta al maestro a usar una Caja Feliz con luces; la Caja Feliz se mantendrá encendida siempre y llegue la luz que entra por la ventana a los paneles solares.)	
	Reduce el impacto ambiental negativo	**Describe cómo el proyecto minimiza los impactos ambientales negativos** (Ej. Nuestro proyecto, creado con paneles solares para producir electricidad renovable, no emite CO_2 porque no usamos la electricidad del enchufe de la pared, que suele producirse por la combustión de carbón.)	
Prácticas de ingenieriá	Soluciones de ingeniería	**Describe el proceso de ingeniar una solución para el problema** (Ej. Construimos un circuito en serie, pero no función, así que intentamos hacer un circuito en paralelo que sí funcionó.)	
Conocimiento de contenido energético	Tipos de energía	**Describe el proceso de decidir cuál fuente de energía se utilizaría** (Ej. Esto se colocará al borde de la ventana donde entra la luz solar, así que decidimos usar energía renovable de paneles solares.)	
	Flujo de energía	**Describe el proceso de diseñar un circuito de trabajo** (Ej. Dibujamos un circuito en serie, pero no función cuando lo probamos, así que lo cambiamos a un circuito paralelo y funcionó.)	
	Transformación energética	**Explica cómo la energía se transfirió al circuito** (Ej. Cuando usamos la manivela al extremo del circuito, ocasionó que el mango de la manivela que conectamos al otro extremo del circuito se moviera. La energía cinética se convirtió en energía eléctrica y entonces se convirtió en energía cinética.)	
Identidad	Presentaciones	**Describe a los miembros del grupo, sus intereses, experiencias, y su ubicación general.**	

Nota: Los trabajos escritos de las hojas de trabajo de **las lecciones 1–10** se pueden usar para el texto de las postales.

ENGINEERING for
SUSTAINABLE COMMUNITIES

LESSON 11

How can I assess my engineering design's impact in my community?

Background for Teachers
This lesson will be co-developed with students and teachers throughout the I-Engineering Unit and over winter break. Slight changes have been made throughout the unit to support the engineering designs to be used throughout the rest of the year.

ANALYZING ENGINEERING DESIGNS' IMPACT

DRIVING QUESTION

What do I want others to know about my engineering design for sustainable communities?

Overview

In this repeating monthly lesson, youth will track and analyze how their engineering design solutions are addressing their community's needs. They will design ways to collect and then evaluate quantitative and qualitative data gathered through critical ethnography. They will then refine their engineering designs to better meet their goals based on their analysis.

Objective
Students will refine their engineering design solutions based on community-centered evidence.

'I Can' Statement
I will refine my engineering design solution to better support my community.

Materials
None

Equipment
None

Handouts
None

ACKNOWLEDGMENTS

> **You know how when you do something nice for someone else and your heart feels big? That is how I felt.**
>
> MALIA

I-Engineering Collaborators

Angela Calabrese Barton University of Michigan
Edna Tan University of North Carolina at Greensboro
Scott Calabrese Barton Michigan State University
Kathleen Schenkel University of Michigan
Aerin Benavides University of North Carolina at Greensboro
Christina Restrepo Nazar Michigan State University
Marcos González Flores Michigan State University
Alex Mirabel Michigan State University

Alexa Carducci
Anna Romsek
Barbara Jackson
Jami Brown
Karla Pavey
Katerin Duran Batista
Kurt Meis
Martha Kefgen
Marynia Lorencen
Sarah Curry
Selena Bliesener
Therese Strohmer
Veronica Huver
Gina DiFrancesco
Beverly Howard
Emma Linn
Kenneth Melton
Derek Meyers
Maria Morales
Heather Schaffer
Katie Selway
Emily Aron
Josh Johnson
Molly McGinnis
Olivia Eiden
Chelsey Wiersma
Rachel Dodds
Chelsea McCue
Sarah Stief
Sarah Przybylo
Brooke Lewandowski
Olivia Corcoran
Chehak Arora
Anna Burgess

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It says I am determined. I can push through, and that I care about people. I am creative and smart.

SAGE, *on how the electric art she designed represents her.*

For more information on i-Engineering

Angela Calabrese Barton **angiecb@umich.edu**
Edna Tan **e_tan@uncg.edu**