The Past, Present, and Future of Microelectronics

Grades 7-9

DRAFT

SCALE K-12

SCalable Asymmetric Lifecycle Engagement

PURDUE UNIVERSITY | INSPIRE Research Institute for Pre-College Engineering

INDIANA UNIVERSITY
SCHOOL OF EDUCATION
Bloomington

ROI REGIONAL OPPORTUNITY INITIATIVES

Cover Information

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Unit Title: The Past, Present, and Future of Microelectronics
Grade Level Range: Grades 7 - 9

Acknowledgments

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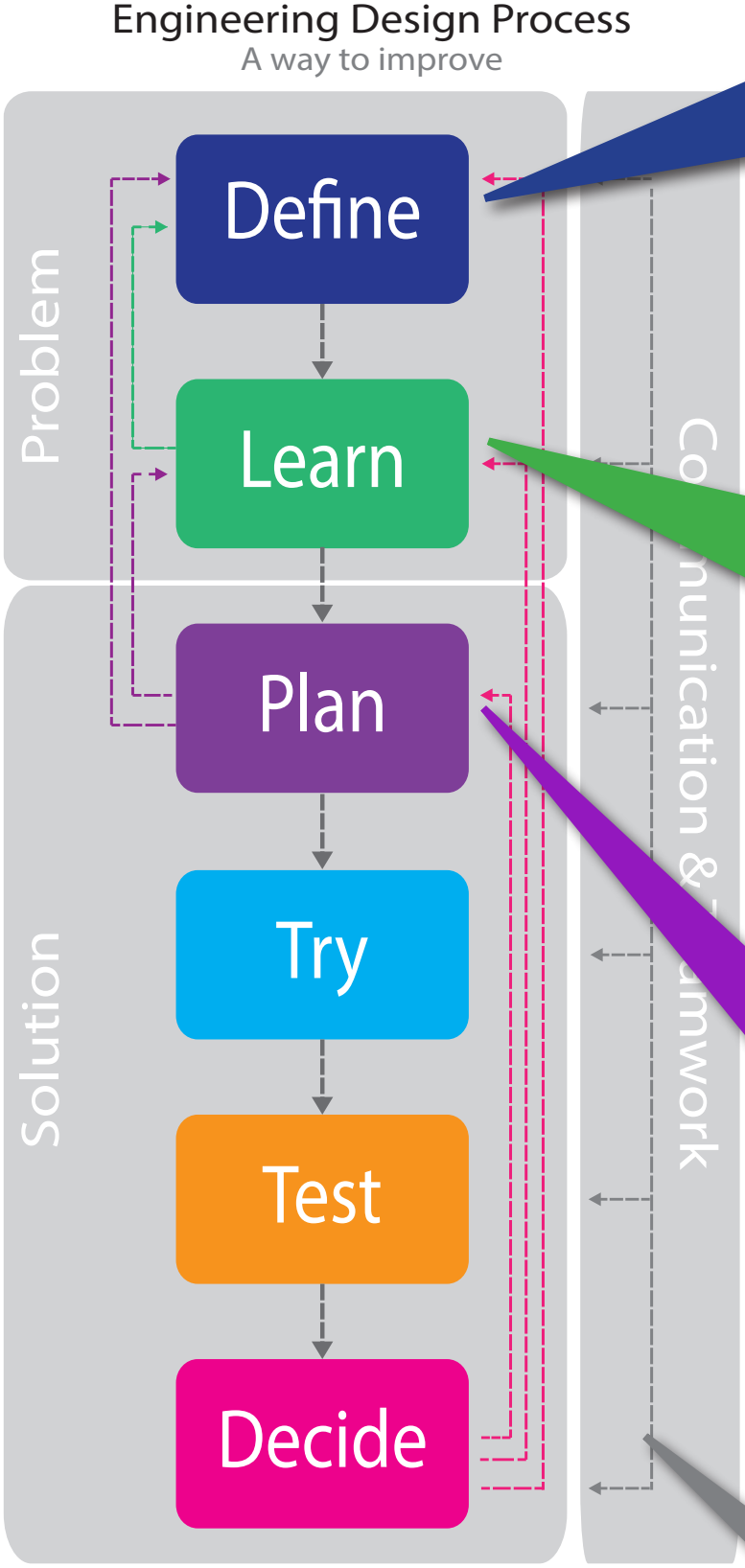
Overview: Engineering Design Process



DEFINE THE PROBLEM

- Who is the **client**?
- What does the client need?
- Why does the client need it?
- Who is the **end user**?
- Why might the end user want it?
- What are the **criteria** (requirements)and **constraints** (limits) of the solution?

Problem Scoping:
WHO needs **WHAT** because **WHY**

LEARN ABOUT THE PROBLEM

- What kind of background knowledge is needed?
  - What science/math knowledge will be needed?
  - What materials will be needed?
- What has already been done to solve the problem?
- What products fill a similar need?
- How should we measure success and improvement?

PLAN A SOLUTION

- Continue to specify the criteria/ constraints
- Generate ideas of possible solutions
- Develop multiple solution paths
- Consider **constraints, criteria**, and **trade-offs** (criteria that compete with one another)
- Choose a solution to try
- Develop plans (blueprints, schematics, cost sheets, storyboards, notebook pages, etc.)

COMMUNICATION

- Communicate the solution clearly and make sure it is easily understandable
- Use **evidence** to support why the client should use your solution

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Overview: Engineering Design Process

TRY A SOLUTION

- Put the plan into action
- Consider risks and how to optimize work
- Use criteria/constraints and consider trade-offs from the problem/plan to build a **prototype** (a testable representation of a solution), **model**, or **product**

TEST A SOLUTION

- Consider testable questions or hypotheses
- Develop experiments or rubrics to determine if the solution is meeting the stated criteria, constraints, and needs
- Collect and analyze data

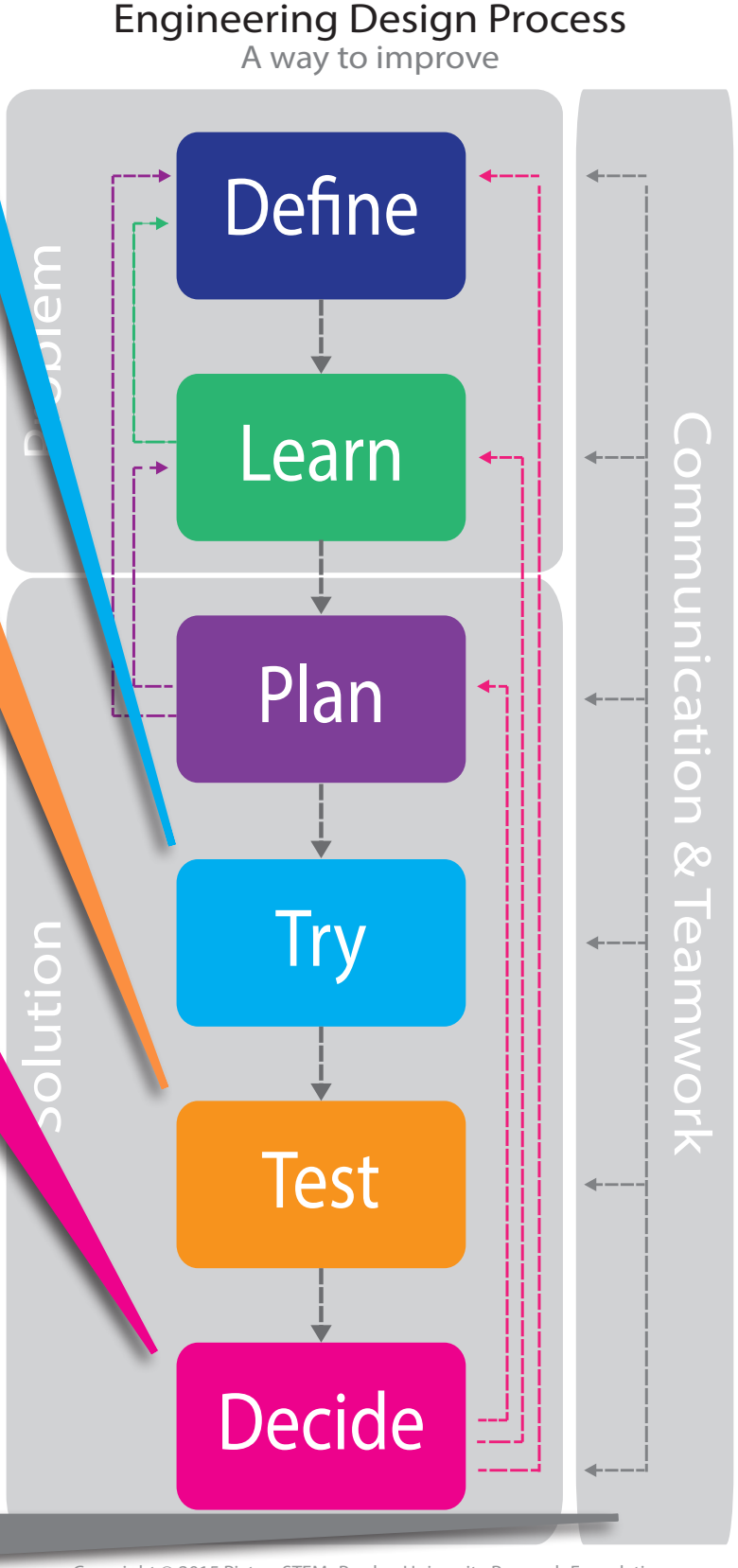
DECIDE IF THE SOLUTION IS GOOD ENOUGH

- Are users able to use the design to help with the problem?
- Does the design meet the criteria and constraints?
- How could the design be improved based on test results and feedback from the client/user?

Iterative nature of design: Always consider which step should be next!

TEAMWORK

- Discuss in teams how the solution meets the criteria and needs of the client
- Consider different viewpoints from each teammate



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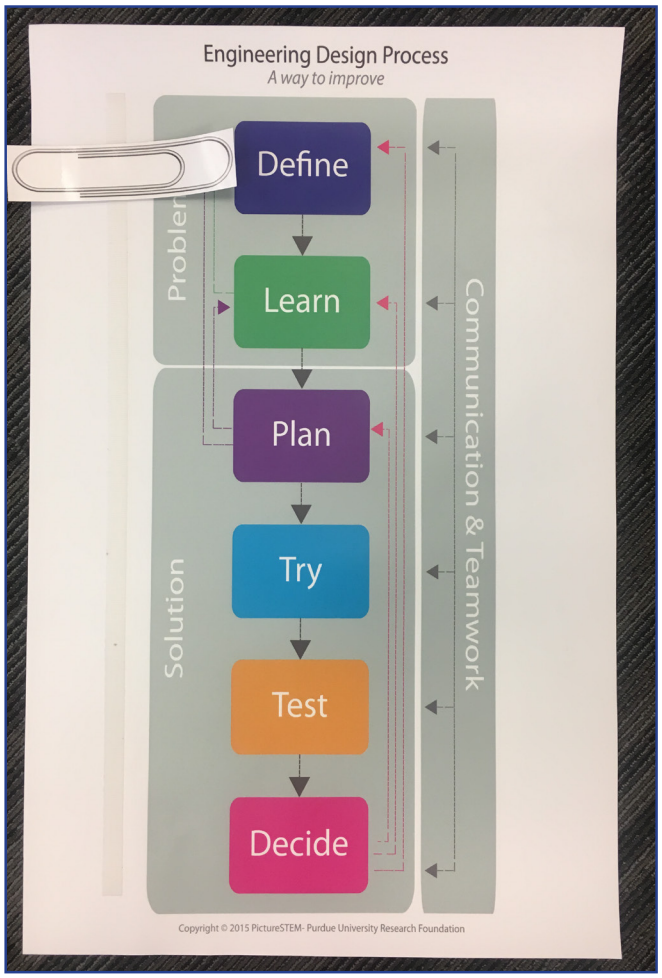
Overview: How to make EDP sliders

How to create the poster

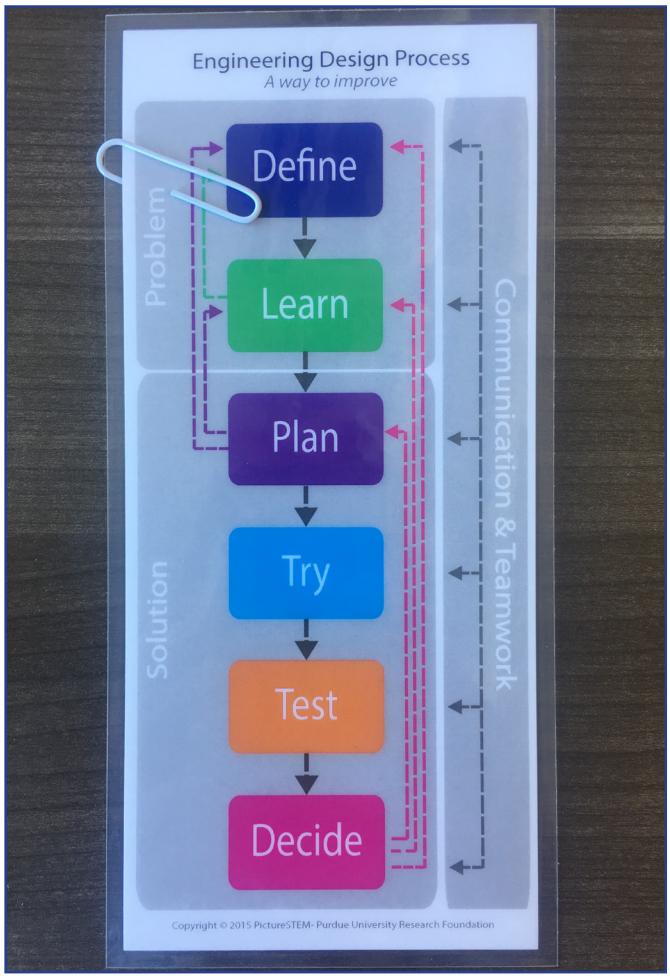
1. Download the high-quality PictureSTEM Slider Poster and the paper clip images from PictureSTEM.org.
2. Print the poster and the paper clip on poster-sized paper and cut to size. High-gloss or semi-gloss paper is the best choice.
3. Use self-sticking Velcro on the back of the paper clip and down the side of the poster so that the paper clip can be placed to point at all 6 sections of the slider.

How to create individual sliders

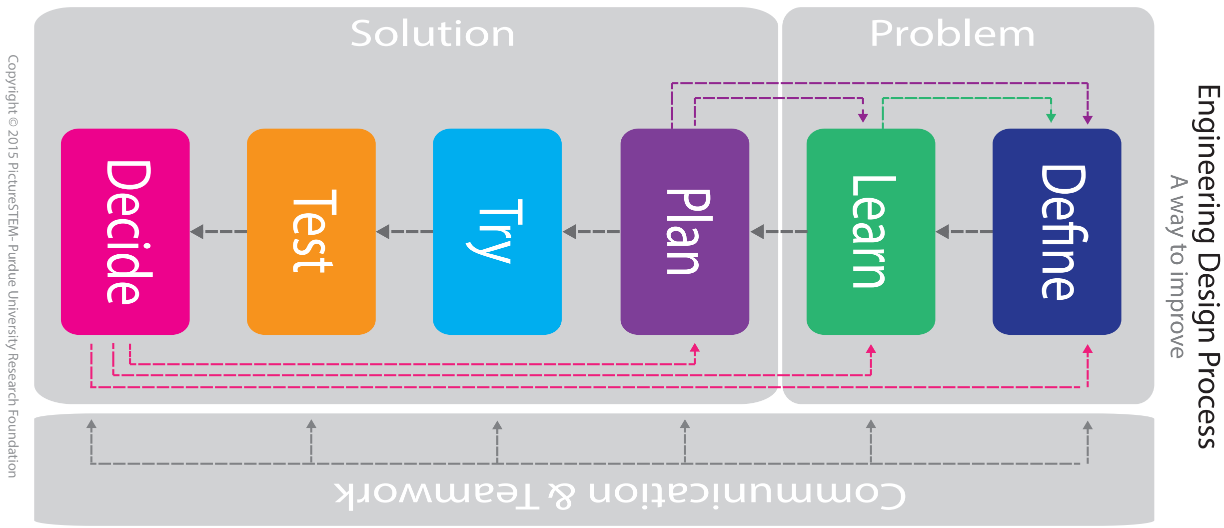
1. Print the sliders on the opposite page - enough for one slider per student in your class.
2. Cut the sliders apart.
3. Laminate the sliders individually.
4. Use a jumbo paper clip as the pointer for each slider.



Poster



Individual slider


Engineering Design Process
A way to improve
Problem
Solution
Define
Learn
Plan
Try
Test
Decide
Communication & Teamwork
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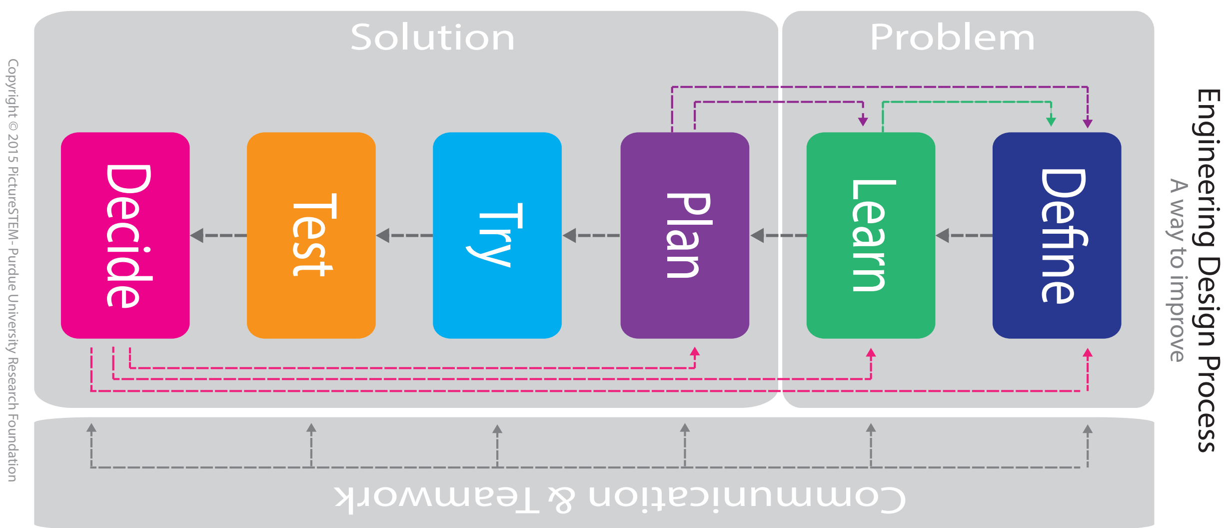
Engineering Design Process
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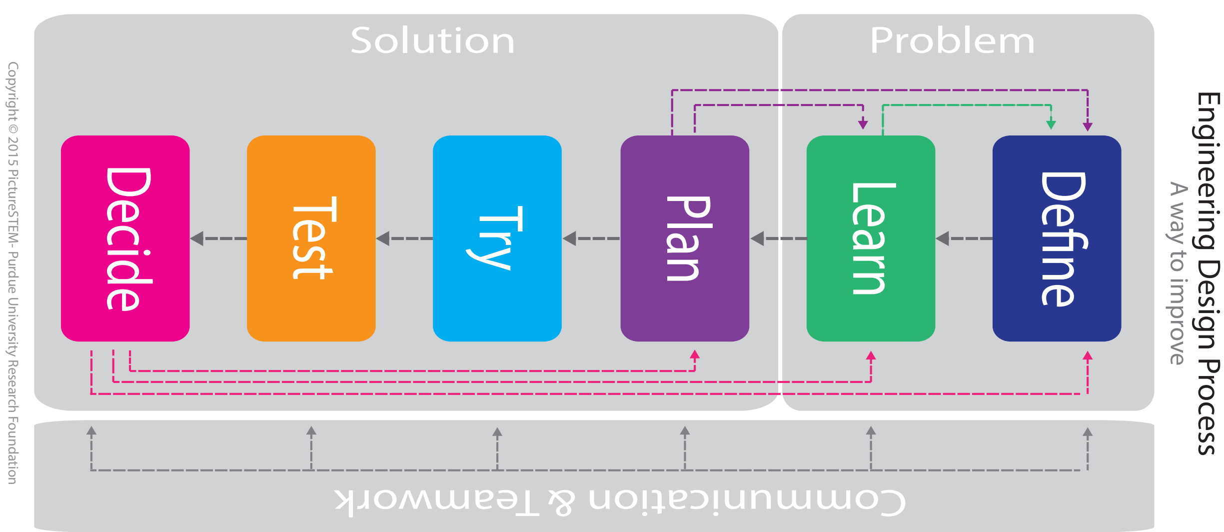
Engineering Design Process
A way to improve
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Unit Overview

Grade Levels: Grades 7 - 9

Approximate Time Needed to Complete Unit: 2 Weeks

Unit Summary

The unit introduces grades 7-9 students to the field of Microelectronics (ME) in an age-appropriate way. Students develop a clear understanding of what ME products are, ME-related careers, the impact of ME in our daily life, and the overall importance of ME.

Standards

IN Preparing for College and Careers (PCC)
PCC 2.1 2.2. 2.4. 6.3 6.4 7.4
PCC-2.1 Determine roles, functions, education, and training requirements of various career options within one or more career clusters and pathways
PCC-2.2 Analyze career trends, options and opportunities for employment and entrepreneurial endeavors for selected career clusters and pathways
PCC-2.3 Evaluate selected careers and pathways for education requirements, working conditions, benefits, and opportunities for growth and change
PCC-2.4 Use appropriate technology and resources to research and organize information about careers
PCC-6.3 Social and Cross-Cultural Skills

- Interact effectively with others in a respectable, professional manner
- Respect cultural differences and work effectively with people from a range of social and cultural backgrounds
- Respond open-mindedly to different ideas and values
- Leverage social and cultural differences to create new ideas and increase both innovation and quality of work

PCC-6.4 Productivity and Accountability Demonstrate additional attributes associated with producing high quality products including the abilities to:

- Work positively and ethically
- Manage time and projects effectively
- Participate actively, as well as be reliable and punctual
- Present oneself professionally and with proper etiquette
- Collaborate and cooperate effectively in teams
- Be accountable for results

PCC-7.4 Demonstrate standards of legal and ethical behavior in human, cultural, and societal issues related to technology and digital citizenship

7-E-1 Compare and contrast informational text

MS-PS1-3 Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.

Lesson Summaries

Lesson 1: What is microelectronics?
Students will begin the unit by receiving a letter from their client asking for their help defining the future of microelectronics careers. The class will then learn what the field of microelectronics is, how they're used in daily life, and how the materials are mined to make microchips.

Lesson 2: Tiny Microelectronics, Big Impact!
In a second letter, the client shares a need for more help in understanding microelectronics as students continue to think about career opportunities related to jobs in microelectronics. Students will learn how microelectronics waste affects the environment by looking at the product life cycle, will learn about the elements that make up cell phone components, and will learn about the components of a micro:bit while developing insights on the rapid evolution of its technology.

Lesson 3: Careers in Microelectronics
Students will learn about various career opportunities within the field of ME. They will choose three ME-related careers that interest them, conduct research and collect information about them, and make a presentation about their chosen careers and why they find them appealing. This lesson aims to foster an interest in ME and will provide insights into potential future career paths.

Lesson 4: Ethics – Make Your Case
Students will critically analyze and present arguments for and against microelectronics technology, considering ethical, social, economic, and environmental perspectives. They will engage in a courtroom-style debate to defend their positions as either proponents or opponents of microelectronics.

Unit Overview

Unit Planner

Lesson	Time Needed	Objectives	Duplication Master
1. What is microelectronics?	100 minutes	• Define the term, “microelectronics” • Identify microelectronics in their daily life • Explain why access to microelectronics is important • Explain how microelectronics start as a resource and develop into a product for sale	1.A Content Pre-Assessment 1.B Problem Scoping Prompts 1.C Client Letter 1.D Microelectronics Image 1.E Microelectronics in Daily Life 1.F Microelectronics Research 1.G Resource to Product
2. Tiny Microelectronics, Big Impact!	100 minutes	• Define the role of microelectronics through conceptualizing, quantifying, and representing microelectronics in everyday use. • Describe the product lifecycle for electronics and identify options for e-waste in your community • Identify elements used in cell phones and describe their properties, importance, and recycling rates • Identify the main components of the micro:bit, describe their functionality and how they simulate the functionality of cell phone components. • Develop and share insights on the rapid evolution of the technology.	2.A Station 1: Microelectronics Usage and Lifecycle – Instructions 2.B Station 1: Cell Phone and Tablet Usage Tracker 2.C Station Reflections 2.D Station 1: Product Lifecycle Diagram 2.E Station 2: Microelectronic Materials – Instructions 2.F Station 2: Elements of a Smartphone 2.G Station 2: Periodic Table of Mobile Phone Elements 2.H Station 2: Recycling Rates of Smartphone Metals 2.I Station 3: Exploring Microelectronic Components – Instructions 2.J Station 3: micro:bit Components used to simulate Cellphone Capabilities 2.K Compare micro:bit Designs & Specifications 2.L Client Letter #2 2.M Vocabulary
3. Careers in Microelectronics	150 minutes	• Explore various career opportunities in the field of ME • Gain insights into the roles, skills, and educational paths required for ME related jobs • Create a presentation on their chosen ME-related careers	3.A List of ME-related Careers 3.B Career Survey

Lesson	Time Needed	Objectives	Duplication Master
4. Ethics – Make Your Case!	100 minutes	• Research and present information around the ethics of microelectronics • Communicate their chosen roles and contributions during the interactive classroom simulation. • Demonstrate teamwork and cooperation while working together to develop their case • Gain an understanding of various career connections within the microelectronic industry and their legal and ethical implications.	4.A Make Your Case 4.B Oh the Places We Can Go: Exploring Jobs in the Microelectronic Industry 4.B Oh the Places We Can Go: Exploring Jobs in the Microelectronic Industry (ANSWER KEY)

Master Material List

	Unit Materials	Lessons Where Material is Used
Per classroom	Chart Paper/Large Post-Its 3 workstation locations Popsicle sticks (10 per student at workstation 1; A pack of 300 for class) micro:bit (Optional, 1 per class)	1 2 2 2
Per Group (assume 3 students per group)		
Per Student	Laptop/Chromebook/Tablet Notebook Pens or pencils and erasers	1,2,3,4 1,2,3,4 1,2,3,4

LESSON ONE:

Lesson Objectives
Students will be able to:
- Define the term, "microelectronics"
- Identify microelectronics in their daily life
- Explain why access to microelectronics is important
- Explain how microelectronics start as a resource and develop into a product for sale

Time Required
Two 50-minute lessons

Standards Addressed
PCC 2.1, PCC 2.2
7.E.1

Key Terms
Microelectronics, semiconductor, production, distribution, consumption

Lesson Materials
Per classroom
- Chart paper/Large Post-Its

Per Student
- Laptop/Chromebook/ Tablet
- Notebook
- Pens or pencils and erasers

Lesson Summary

Students will begin the unit by receiving a letter from their client asking for their help defining the future of microelectronics careers. The class will then learn what the field of microelectronics is, how they're used in daily life, and how the materials are mined to make microchips.

Classroom Instruction

Introduction

1. **Complete the pre-assessment activity (Optional).** The students will participate in a more formal pre-assessment to assess their current level of knowledge and understanding regarding microelectronics and relevant career paths. Using the questions on the 1.A Content Pre-Assessment, distribute hard copies or have students respond to a digital version of the survey. Make sure to tell students that this is just to assess any prior knowledge, so it is okay to not know the answers. Do NOT provide answers to students while they complete the assessment.
2. **Review prior knowledge.** Lead a discussion with the class in which students are able to share their prior knowledge on the topics of ethics and microelectronics. Prompts may include the following: *What are microelectronics? What are some careers related to microelectronics?*
3. **Set up notebooks. Say:** *You will also be using notebooks throughout our lessons. Each day, you'll use the notebooks to take notes and record what you are learning. In addition, there are questions that you'll be asked to answer.* NOTE: You can have your students write in their notebooks in two different colors – one for thoughts and prompts that are individual and one for thoughts and prompts that they discuss in their teams. This will help both you assess, and the students recognize, where ideas came from. You also may want to have students start a Table of Contents page.
4. **Form teams.** Explain that students will be working in small teams to solve a problem being brought to them by the client. Divide students into teams of 3 or 4.

Activity

Part I (Day I): Problem Scoping

5. **Introduce the problem.** Allow students time to read copies of Duplication Master 1.B Client Letter. Encourage them to write in their notebooks as they read to keep track of important information. Give students time to discuss in small teams what information they read in the letter. **Ask:** *What is the challenge? What are some possible constraints and criteria?*
6. **Identify the problem from the client.** Have the students reread the letter, if necessary, to identify the problem and write it in their notebooks.
7. **Identify required information.** Have students work together to brainstorm a list of "required information" in order to help the client with their request. Encourage them to highlight/underline the things on their list they already know. Then as a class create an anchor chart that will be revisited throughout the unit. As students learn information you can check content off of the anchor chart or add to it if they think of some other information that they will need to help the client.
8. **Complete problem scoping section 1.** After reading the letter, direct students to respond to section 1 of 1.C Problem Scoping Prompts in their notebooks. They can do this individually or in teams.
9. **Complete problem scoping section 2. A**fter students have completed the section 1 prompt, direct students to section 2 of 1.C Problem Scoping Prompts. They can do this individually or in teams.

Part II (Day II): Introduction to Microelectronics

10. **Help students identify how often they use microelectronics.**
    Say: *Our client wants us to identify how often we use microelectronics in our daily lives. But first, we need to understand what microelectronics are and why they are critical.*
    Hand out Duplication Master 1.D Microelectronics Image. **Say:** *The field of microelectronics includes the design, manufacture, and use of microchips. Microchips are tiny circuits that exist in many electronic devices. They allow these devices to communicate, process, and store information.*
    If needed, show students the following video from Argonne National Lab.
    https://youtu.be/514-X44rXdQ?si=niiasddFq50djP4Y

Duplication Masters

1.A Content Pre-Assessment (Optional)
1.B Problem Scoping Prompts
1.C Client Letter
1.D Microelectronics Image
1.E Microelectronics in Daily Life
1.F Microelectronics Research
1.G Resource to Product

Educator Resources

1.H Content Pre-Assessment KEY
1.I Problem Scoping Section 3 KEY
1.J Microelectronics Research KEY
1.K Resource to Product KEY

11. **Hand out Duplication Master 1.E Microelectronics in Daily Life. Say:** *Individually, come up with 10 products you use at least once or twice per week that are microelectronics.* The teacher may allow students to work together in teams for this activity.
12. **Provide time for students to research the importance of access to microelectronics. Say:** *Now that you see how many microelectronics you use in a day, you can understand why they are so important!* Hand out Duplication Master 1.F Microelectronics Research. **Say:** *In your groups, answer these questions about why microelectronics is important.* Allow students to use their tablets or laptops to answer the questions. Tell them that they will need to include the resources from which they obtained the information in 1.F.
13. **Discuss why microelectronics is important as a class.** Lead the class in a discussion debriefing their answers to Duplication Master 1.F Microelectronics Research.
14. **Provide time for students to research the production to distribution to consumption path. Say:** *Now you know why microelectronics are so important! Let's take a few minutes to complete the final task from our client and learn about how a product starts as a natural resource and ends up for sale in a store.* Hand out Duplication Master 1.G Resource to Product. **Say:** *In your groups, answer these questions about the path of microelectronics.* Allow students to use their tablets or laptops to answer the questions.
15. **Discuss the path of microelectronics as a class.** Lead the class in a discussion debriefing their answers to Duplication Master 1.G Resource to Product.

Closure

16. **Revisit the problem.** Give the students a chance to revise their list of questions or required information they composed for the client's challenge.

What is microelectronics?

Name_____ Date_____ Period _____

1.A Content Pre-Assessment (Optional)

1. What does the term, “microelectronics” mean?

2. How are microelectronics used in your everyday life?

3. What jobs would you be interested in that use microelectronics?

4. Provide one example of how microelectronics is used in that job.

1.B Client Letter

Dear Students,

Microelectronics and semiconductors have become vital to society due to their prevalence in personal, consumer, business, and military technologies. Recently, the United States has made a major economic shift from being primarily purchasers of microelectronics to being manufacturers. As the US builds its microelectronics workforce, the number of job opportunities is exponentially increasing. There will be an anticipated 114,800 industry jobs available by 2030 with training requirements ranging from certificates or two-year degrees to PhDs.

My company works to help people find careers in which they will excel and be happy employees. We specialize in finding careers for folks in electrical and computer science. It is important that people work in a job that they enjoy so companies don't end up with a lot of employees quitting. With all of the new microelectronics jobs that will be available over the next few years, I would like to provide some of these career paths as options to our clients. However, I don't know what the field of microelectronics will look like in the future.

I want to enlist your help to provide us with predictions on the future of the field of microelectronics. These predictions must be as accurate as possible, but we do recognize that it is very difficult to make industry predictions. Your first three tasks are to:

1. Identify how you use microelectronics in your daily life.
2. Gain a basic understanding of the field of microelectronics.
3. Learn about how a product starts as a natural resource and ends up as a device in a store.

Please learn about this process and report back to me with your findings. I am looking forward to working with you!

Sincerely,

Sam Springs

Sam Springs
Career Consultant
Jumpstart Jobs

Name_____ Date_____ Period _____

1.C Problem Scoping Prompts

Section 1:
Directions: Please answer the following question after hearing about your task from the client.

1. What questions do you want to ask the client?

Section 2:
Directions: Please answer these questions after you have been able to ask questions about the challenge. First, complete each prompt on your own. Then write your revised answer (if different) to the prompt, based on the discussion with your team. You may use a different color writing utensil to distinguish your answer and how it changed after talking with teammates.

2. The client is:

3. The client's problem is:

4. The problem is important to solve because:

5. The end-users are:

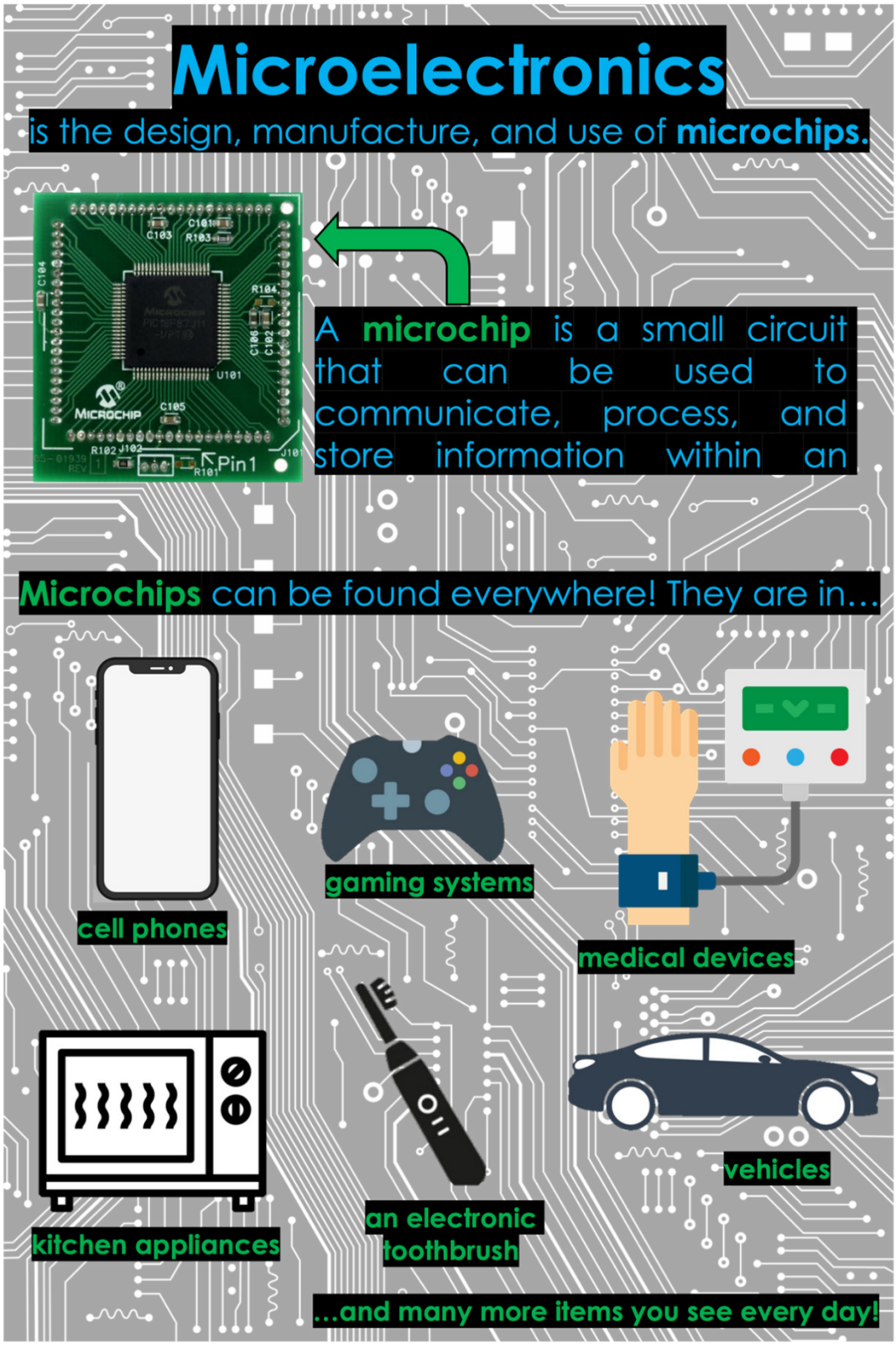
6. An effective solution for the client will meet the following criteria:

7. The constraints (or the limits) of the solution are:

8. Think about the problem of finding careers related to microelectronics. In terms of helping the client, what are at least 2 things you need to learn in order to make a research-driven recommendation? Make sure to consider all important aspects of the problem. Be specific.

Name_____ Date_____ Period _____

1.D Microelectronics Image



Name_____ Date_____ Period _____

1.E Microelectronics in Daily Life

What microelectronics do you use in everyday life? Think of examples of products that you use at least once or twice per week. List your microelectronic products below.

1. _____

2. _____

3. _____

4. _____

5. _____

6. _____

7. _____

8. _____

9. _____

10. _____

Name_____ Date_____ Period _____

1.F Microelectronics Research

Answer the following questions in full sentences.

1. **The world is currently experiencing a “chip shortage”. What does this mean?**

2. **How does microelectronics help police officers?**

3. **How does microelectronics help people in the medical field?**

4. **How does microelectronics help improve the USA’s relationship with other countries?**

5. **What would life be like if you didn’t have access to any microelectronics for one week?**

6. **Include the resources from which you obtained the above information.**

Name_____ Date_____ Period _____

1.G Resource to Product

Answer the following questions in full sentences.

Production – How are microchips made?

1. The first step to making a microchip is extracting an element from sand. What is the element?

2. How is that element extracted from sand and purified?

3. List **three** steps in the microchip manufacturing process.

Distribution – Where are microchips transported?

4. List **three** countries that manufacture microchips.

5. If a company in Paraguay wanted to sell microelectronic products, how far would the microchips have to travel from each of the three countries you found in the previous question? Provide your answers in **miles**.

Name_____ Date_____ Period _____

1.G Resource to Product

Consumption – Who buys microchips?

6. What **three** countries sell the most microelectronic products?

7. What is your favorite microelectronic product that you use?

Name_____ Date_____ Period _____

1.H Content Pre-Assessment KEY

1. What does the term, “microelectronics” mean?

   Student answers may vary, but the formal definition of microelectronics is the design, manufacture, and use of microchips.

2. How are microelectronics used in your everyday life?

   There are many answers to this question, but examples include…

3. What jobs would you be interested in that use microelectronics?

   Students’ answers will vary based on interest. Credit may be given as long as at least one job example is provided.

4. Provide one example of how microelectronics is used in that job.

   Students’ answers will vary based on interest. Credit may be given as long as at least one example is provided of how microelectronics is used in the job they provided in question nine.

1.I Problem Scoping Section 3 KEY

Section 2:

2. The client is:

   Sam Springs at Jumpstart Jobs.

3. The client's problem is:

   They don't know what the future will look like for the field of microelectronics.

4. The problem is important to solve because:

   There will be an anticipated 114,800 jobs available in microelectronics by 2030.

5. The end-users are:

   Clients of Jumpstart Jobs looking for a career in microelectronics.

6. An effective solution for the client will meet the following criteria:

   The prediction of the future of microelectronics will be as accurate as possible.

7. The constraints (or the limits) of the solution are:

   It is very difficult to predict the future of industry careers.

8. Think about the problem of finding careers related to microelectronics. In terms of helping the client, what are at least 2 things you need to learn in order to make an evidence-based recommendation? Make sure to consider all important aspects of the problem. Be specific.

   Answers will vary. Potential ideas include what microelectronics are, what kinds of jobs are available, how much education is needed for jobs, etc.

1.J Microelectronics Research KEY

1. The world is currently experiencing a “chip shortage”. What does this mean?

   The global chip shortage is the problem that from 2020 – 2023, the world did not have enough microchips being manufactured to meet the demand for them. This was primarily caused by the COVID-19 pandemic but was supplemented by trade war between the US and China, and a drought in Taiwan.

2. How does microelectronics help police officers?

   There are many answers to this question. Examples include the radios that officers use to communicate with another, the sirens on their cars, computer equipment in their cars, computers at the police station, etc.

3. How does microelectronics help people in the medical field?

   There are many answers to this question. Examples range from blood pressure machines, electric thermometers, and heart rate monitors to x-ray machines, IV drips, and MRIs.

4. How does microelectronics help improve the USA’s relationship with other countries?

   Examples include: Microelectronics allow us to communicate quickly with other countries. They also allow us to travel quickly to other countries in cars, boats, or planes. Since the US has started manufacturing microelectronics, we are now suppliers of microelectronics and can improve our trade relationships.

5. What would life be like if you didn’t have access to any microelectronics for one week?

   Answers will vary. Credit may be given as long as students provide a thoughtful answer about what their experience would be like.

1.K Resource to Product KEY

Answer the following questions in full sentences.

Production – How are microchips made?

1. The first step to making a microchip is extracting an element from sand. What is the element?

   The element extracted from sand to make microchips is silica.

2. How is that element extracted from sand and purified?

   Carbon is added to the sand and then heated at very high temperatures.

3. List **three** steps in the microchip manufacturing process.

   Some steps include cleaning, deposition, photoresist coating, photolithography, etching, ion implantation, and packaging. There are other steps that would also be correct to list.

Distribution – Where are microchips transported?

4. List **three** countries that manufacture microchips.

   Countries that manufacture microchips include Britain, China, Germany, Japan, Malaysia, the Netherlands, the Philippines, Singapore, South Korea, Taiwan, and the United States.

5. If a company in Paraguay wanted to sell microelectronic products, how far would the microchips have to travel from each of the three countries you found in the previous question? Provide your answers in **miles**.

Britain: 6,305 miles
China: 11,136 miles
Germany: 6,617 miles
Japan: 11,075 miles
Malaysia: 10,863 miles
The Netherlands: 6,474 miles
The Philippines: 11,723 miles
Singapore: 10,490 miles
South Korea: 11,502 miles
Taiwan: 12,359 miles
The United States: 4,843 miles

Consumption – Who buys microchips?

6. What **three** countries sell the most microelectronic products?

The three countries that manufacture/sell the most microchips are Taiwan, South Korea, and Japan.

7. What is your favorite microelectronic product that you use?

An answer may be marked as correct as long as it is a microelectronic product.

LESSON TWO:

Lesson Objectives
Students will be able to:

- Define the role of microelectronics through conceptualizing, quantifying, and representing microelectronics in everyday use.
- Describe the product lifecycle for electronics and identify options for e-waste in your community
- Identify elements used in cell phones and describe their properties, importance, and recycling rates
- Identify and describe the functionality of the main components of the micro:bit and how they simulate the functionality of cell phone components.
- Develop and share insights on the rapid evolution of the micro:bit technology

Time Required
Two 50-minute class periods

Standards Addressed
PCC 6.3, PCC 6.4, MS-PS1-3

Lesson Summary

In a second letter, the client shares a need for more help in understanding microelectronics as they continue to think about career opportunities related to jobs in microelectronics. Here students will learn about usage rates of microelectronics within their daily lives and what happens to when microelectronics become obsolete. Additionally, students will break down the elements used in cell phones, identify why they are important to the functionality of the cell phone, and how easy the elements are to recycle. Finally, by exploring the components of a micro:bit and its evolution over 4 years, students will identify how the micro:bit represents the microelectronics inside a cell phone and will generate insights on the rapid evolution of microelectronics.

Students are actively engaged in learning about microelectronics through three workstations:

- **Station 1: Microelectronics Usage and Lifecycle.** Students will estimate their team's cell phone and tablet ownership for the last two years. Using these estimates, students will discuss the impact of that number and what happens when the devices are no longer used. Students will be able to:
  - Define the role of microelectronics through conceptualizing, quantifying, and representing microelectronics in everyday use.
  - Describe the product lifecycle for electronics and identify options for e-waste in your community.
- **Station 2: Microelectronic Materials.** Students will learn about the materials that make up a cell phone while identifying properties and importance of the materials. Students will be able to:
  - Identify the elements used in cell phones
  - Identify the properties, importance, and recycling rate of elements used in cell phones
- **Station 3: Exploring Microelectronic Components.** Students will explore the main components of the micro:bit and identify how micro:bit components simulate the capabilities of cell phone components. Students will reflect on the rapid advanced in technology by comparing different versions of the mirco:bit and predicting future advances. Students will be able to:
  - Identify and describe the functionality of main components of the micro:bit and how they can be used to simulate the electronics in a cell phone
  - Develop and share insights on the rapid evolution of the micro:bit technology

Teacher Background

In this lesson, students receive an updated letter form the client asking for more help in understanding microelectronics. It is important to understand that as we navigate a client's needs, more questions arise before we can generate a solution. The workstations in this lesson will help address the client's request for information on device usage and obsolescence, materials used in microelectronic components, and insights on the rapid evolution of the technology.

If students have questions about actual careers in microelectronics, reinforce that they are good questions, ask the student to write those questions in their notebook, and assure them that these questions will be explored in the next lesson.

If students are not familiar with the vocabulary, consider spending class time reviewing the vocabulary terms listed on 2.M Vocabulary.

Vocabulary:	Microelectronics, obsolescence, product lifecycle, e-waste, recycle, upcycle, element, properties, micro:bit, microcontroller, processor, input/output peripherals, input, output https://www.anl.gov/science-101/microelectronics

Key Terms

Microelectronics, obsolescence. product lifecycle, e waste, recycle, upcycle, element, properties, micro:bit, microchip, microcontroller, processor, input, output, input/output peripherals

Lesson Materials

Per classroom

- Three separate workstation locations
- Popsicle sticks – 10 per student at workstation 1
- micro:bit kit (Optional)

Per Student

- Laptop/chromebook/ tablet with internet access
- Notebook
- Pens or pencils and erasers

LESSON TWO:

Duplication Masters
2.A Station 1: Microelectronics Usage and Lifecycle – Instructions
2.B Station 1: Cell Phone and Tablet Usage Tracker
2.C Station Reflections
2.D Station 1: Product Lifecycle Diagram
2.E Station 2: Microelectronic Materials – Instructions
2.F Station 2: Elements of a Smartphone
2.G Station 2: Periodic Table of Mobile Phone Elements
2.H Station 2: Recycling Rates of Smartphone Metals
2.I Station 3: Exploring Microelectronic Components – Instructions
2.J Station 3: micro:bit Components used to simulate Cellphone Capabilities
2.K Compare micro:bit Designs & Specifications
2.L Client Letter #2
2.M Vocabulary

Before the Activity

For each student, make copies of

- 2.C Station Reflections; these will be updated by each student during the activity at each workstation and kept with them throughout the lesson.
- 2.M Vocabulary; students may want to refer to this list as they visit each workstation; consider spending time in class reviewing if students are not familiar with the terms
- 2.L Client Letter #2; this letter will be handed out at the beginning of the lesson

Set up the workstations:

- **Station 1: Microelectronics Usage and Lifecycle**
  - Set the popsicle sticks at this station
  - Make one copy for the workstation
    - ☐ 2.B Station 1: Cell Phone and Tablet Usage Tracker
  - Make one set of copies for each of the teams working at the station at one time (These ***will be*** left for the next team(s) rotating to the workstation)
    - ☐ 2.A Station 1: Microelectronics Usage and Lifecycle – Instructions
    - ☐ 2.D Station 1: Product Lifecycle Diagram

- **Station 2: Microelectronic Materials**
  - Make one set of copies for each of the teams (These will ***NOT*** be left for the next team(s) rotating to the workstation)
    - ☐ 2.E Station 2: Microelectronics Materials – Instructions
    - ☐ 2.F Station 2: Periodic Table of Mobile Phone Elements
    - ☐ 2.G Station 2: Elements of a Smartphone
    - ☐ 2.H Station 2: Recycling Rates of Smartphone Metals

- **Station 3: Exploring Microelectronic Components**
  - If (Optional) micro:bit kit is available, place at this workstation
  - Make one set of copies for each of the teams working at the station at one time (These ***will be*** left for the next team(s) rotating to the workstation)
    - ☐ 2.I Station 3: Exploring Microelectronic Components – Instructions
    - ☐ 2.J Station 3: micro:bit Components Used to Simulate Cell Phone Capabilities

- □ 2.K Station 3 Compare micro:bit Designs and Specifications
- Assure video links are accessible and working

Classroom Instruction

Introduction

1. **Introducing the client problem.** Pass around copies of 2.L Client letter #2. Allow students time to read the letter. Encourage them to write any important information in their notebooks. **Ask:** *Why do you think the client has come back to us with more questions? How will answering these questions help out client understand the fiend of microelectronics and career opportunities?* Encourage students to respond. **Say:** *It is important to understand that as we navigate a client's needs, more questions arise before we can generate a solution.*
2. **Introduce Workstation.** Pass around copies of 2.C Station Reflections. Allow students time to read over the worksheet. **Say:** *Today, we will be rotating through different workstations to conduct our research for the client. At each station, you will engage in activities that explore microelectronics. You will spend 20-30 minutes at each station. I will watch the clock and provide a 10-minute warning and a 5-minute warning before you need to move to the next station. Be sure to budget your time at each station between the individual work and the teamwork. You will record your findings either in your notebook or on the 2.C Station Reflection worksheet.*
3. **Overview of each workstation. Say:** *Let's get an overview of each station before break into teams.*
    - *At Station 1: Microelectronics Usage and Lifecycle, you and your team will estimate your team's cell phone and tablet ownership for the last two years. You will use these estimates to discuss the impact of that number and what happens when those devices become obsolete, thinking through the product lifecycle.*
    - *At Station 2: Microelectronic Materials, you and your team will learn about the materials that make up a cell phone while identifying the material's properties, the importance of the material, and its rate of recycle.*
    - *At Station 3: Exploring Microelectronic Components, you and your team will learn about the components of a micro:bit along with their functionality and similarity to cell phone components, and generate insights on the rapid evolution of microelectronics*

Assessment

Pre-Activity Assessment

Check students' ability to explain microelectronics and their impact on our society.

Activity Embedded Assessment

Walk around and gauge student understanding as they work through the activities in each workstation. Use the Station Reflections for each workstation as a way to recognize student understandings and misconceptions.

Post-Activity Assessment

Check the student teams' understanding of microelectronic usage and product lifecycle, the functionality of materials used in a cellphone, and insights on the rapid evolution of microelectronics.

Activity

4. **Complete each of the stations.** Have the students rotate through each station in the classroom using 2.C Station Reflections to capture their learnings from each station. There should be no more than 2 teams at each station. Spend 20-30 minutes at each station performing the activities indicated.
5. **Stations**
    - **Station 1: Microelectronics Usage and Lifecycle**
      Summary: Estimate your team's cell phone and tablet ownership for the last two years. Use these estimates to discuss the impact of that number and what happens when those devices become obsolete, thinking through the product lifecycle.
      NOTE: *Have the last team at Station 1 calculate the whole class total for the Estimate of cell phones and tablets used by your entire team and their families on 2.B Station 1: Call Phone and Tablet Usage Tracker to be shared during the closure portion of the lesson.*

    - **Station 2: Microelectronic Materials**
      Summary: Learn about the elements that make up a cell phone while identifying their properties, the importance of the element, and their rate of recycle.

    - **Station 3: Exploring Microelectronic Components**
      Summary: Learn about the components of a micro:bit along with their functionality and similarity to cell phone components, and generate insights on the rapid evolution of microelectronics

Closure

6. **Facilitate a discussion on what students learned about microelectronic usage, materials, components, and the rapid pace of technology advances**
    - Have the last team at Station 1 report out on the whole class total for the Estimate of cell phones and tablets used by your entire team and their families on 2.B Station 1: Call Phone and Tablet Usage Tracker. Gather student observations on the impact of this number.
    - Ask questions about the importance of understanding microelectronics, usage, materials, components. Ask questions about the impact microelectronics have today and the impact they will have in the future.
    - Ask questions the rapid pace of technology advances and the impact this might have on our client and their company.

2.A Station 1: Microelectronics Usage and Life Cycle - Instructions

Overview of Activity
As you learned in Lesson 1, **microelectronics** is the design manufacture and use of microchips. In this station, you will define the role of microelectronics through conceptualizing, quantifying, and representing microelectronics in everyday use. You will also explore the product lifecycle for electronics and identify options for e-waste in your community.

Individually:

- Think about electronic devices that you use throughout each day. Based on what you know about microelectronics from Lesson 1, how are microelectronics used in those devices? Write your reflections on 2.C Station Reflections under Activity 1 or in your notebook.
- Try counting how many cell phones and tablets your family has had over the last two years and write that number on 2.C Station Reflections under Activity 1 or in your notebook.
- Once you have your number, get popsicle sticks to represent that amount.

As a team:

- In your teams, take turns discussing how you calculated the two-year usage of cell phones and tablets within your family.
- After everyone has shared, calculate how many cell phones and tablets your team (and families) have used over the last two years. Put all of your popsicle sticks together.
- Once you have that number, write that number on 2.C Station Reflections under Station 1 and share it with the class by writing on 2.B Station 1 – Cell Phone and Tablet Usage Tracker
- As a team discuss the following and write your answers on 2.C. Station Reflections under Station 1 or in your notebook:
  - The numbers you just calculated are for your team. There are about 4.2 million eight graders in the United States! Imagine all those devices!
  - What comes to mind when you see your total team number?
  - **Obsolescence** is the condition of no longer being used or useful. What do you think happens to your electronics when you no longer use them or when they become obsolete?
- As a team discuss 2.D. Station 1 - Product Lifecycle Diagram.
  - **Product Lifecycle** is the period of time from when a product is introduced until it is removed from use. How long do you think the product lifecycle is for a cellphone or a tablet?
  - **E-waste** is any discarded electrical or electronic product. Did you know that to extend the product life cycle of an electronic device so that it is not just thrown away as e-waste, there are additional that stages can be added to life of a product by reusing it in different ways?
    - **Upcycling.** One option is upcycling, which is when a component is repurposed or reused for a different function therefore extending its use time.
    - **Recycling.** The other option is recycling the material. This is when the electronic device is broken down into new raw materials that can reused to make different products.
  - What options to recycle or upcycle e-waste are available to you in your community? Why is it important to have recycle or upcycle options in your community? After your team discusses, write down your thoughts 2.C Station Reflections under Station 1 or in your notebook.

2.B Station 1: Cell Phone and Tablet Usage Tracker

Whole Class Results

Team Number	Estimate of cell phones and tablets used by your entire team and their families
Total	

NOTE: The last team at Station 1 should

- add up the total for the column **Estimate of cell phones and tablets used by your entire team and their families,**
- write the total on this worksheet, and
- share the total during the closure portion of the lesson.

Name_____ Date_____ Period _____

2.C Station Reflections (1 of 2)

Station 1: Microelectronics in everyday life reflections

1. What types of electronic devices do you use throughout each day?

   Based on what you know about microelectronics, how are microelectronics used in those devices?

2. How many cell phones and tablets your family has had over the last two years?

3. What is the total number of cell phones and tablets used by your entire team and their families? What comes to mind when you see the total number?

4. What do you think happens to your electronics when you no longer use them?

5. What options to recycle or upcycle e-waste are available to you in your community? Why is it important to have recycle and upcycle options for e-waste in your community?

Station 2: Microelectronic Materials

1. What do you notice about the Periodic Table of Phone Elements?

2. What element did you choose? What is its importance to the use of a cell phone? Is it easy to recycle the element?

3. What were two other elements that you found interesting? What did you find interesting about them?

Name_____ Date_____ Period _____

2.C Station Reflections (2 of 2)

Station 3: Exploring Microelectronic Components

1. What component did you choose? What is the functionality of the component you chose? What two facts did you learn about your component from watching the video?

2. List three observations of how the components on the micro:bit can simulate the electronics used in a cell phone
    a.

    b.

    c.

3. In comparing micro:bit v1 & v2 designs using 2.K Station 3: Compare micro:bit Designs
    a. List two differences you observed in the detailed schematic drawings of the micro:bit boards
        i.

        ii.

    b. How do these added components increase its similarity to a cell phone?

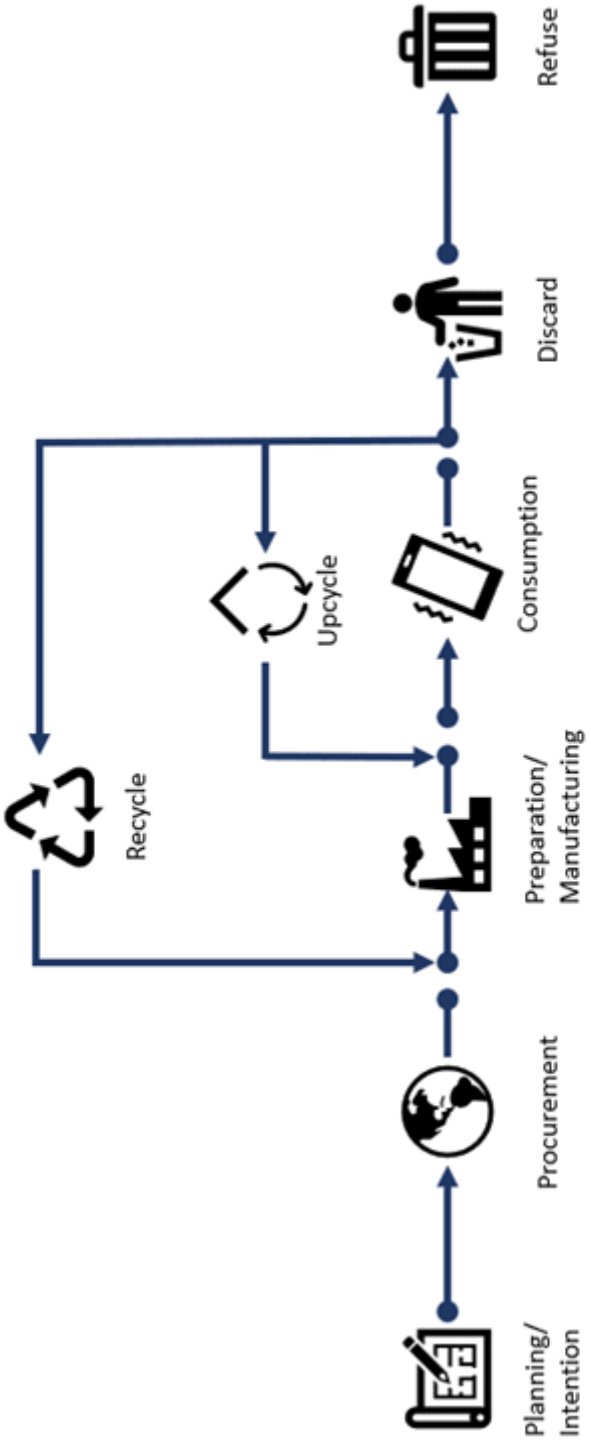
4. (Optional) In comparing micro:bit v1 & v2 designs using 2.K Station 3: Compare micro:bit Specifications
    a. List two differences you observed in the specifications represented
        i.

        ii.

    b. What impact would these differences have if they were experienced in a cell phone?

5. What observations do you have about the changes in technology over the four years between micro:bit v1 and micro:bit 2? What changes might you predict for the next 5 years? 10 years?

2.D Station 1: Product Lifecycle Diagram



Schiffer's lifecycle of durable and consumable elements (Schiffer 1995:29, Fig. 2.2)
Recreated from Walker, W. H., Skibo, J. M., & Fischer, A. (2015). 8. In *Explorations in behavioral archaeology* (p. 100). essay, The University of Utah Press.

2.E Station 2: Microelectronic Materials – Instructions

Overview of Activity
In chemistry, **elements** are substances that cannot be broken down into smaller parts or changed into another substance. Each element has **properties** which uniquely define or identify it. In this station you will identify the elements used in cell phones, their properties, importance, and their rate of recycle.

Individually:

- Many elements are used to make cellphones. It is hard to know the exact number of elements but there are over 55 known elements found in cell phone components. Take a look at some of the elements by reviewing 2.F Station 2: Periodic Table of Mobile Phone Elements. What do you notice about this table?
- Write your observation on 2.C Station Reflections under Station 2 or in your notebook.

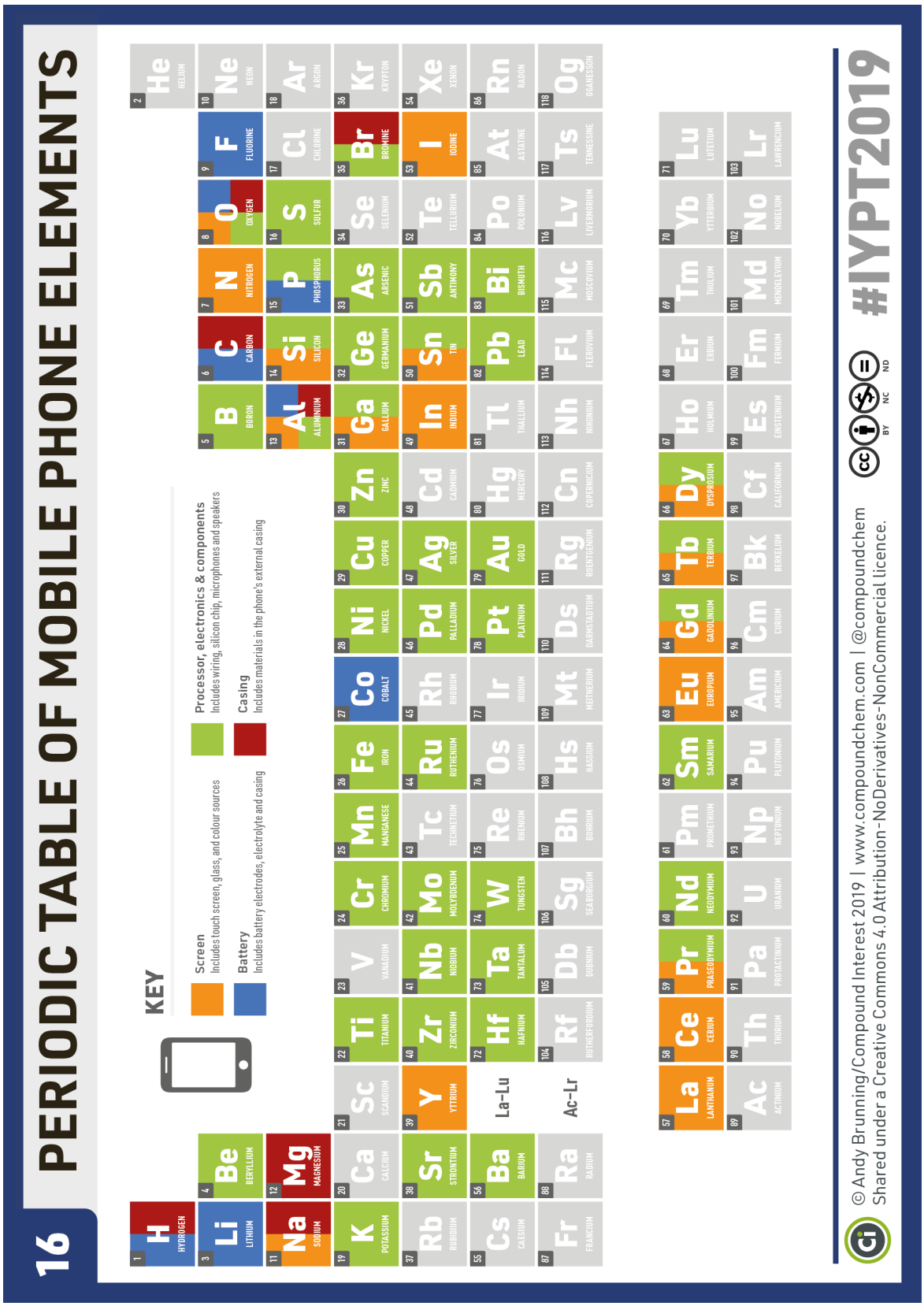
As a Team:

- As a team you will learn more about the elements that make up a some of the components of a cell phone. As a team review 2.G Station 2: Elements of a Smartphone and 2.H Station 2: Recycling Rates of Smartphone Metals
- In your teams discuss the different elements in a cell phone that make the material in a cell phone.
- Have each team member choose one element from either List 1 or List 2 below. Each team member should write their element on 2.C Station Reflections under Station 2 or in your notebook. Note: Each team member should choose a different element.

List 1	List 2
Br - Bromine	Al - Aluminium
O - Oxygen	C - Carbon
In - Indium	Li - Lithium
Dy - Dysporsium	Mg - Magnesium
Co - Cobolt	Sn - Tin
Si - Silicon found in nature as Silica (Silicon dioxide)	Pb - Lead

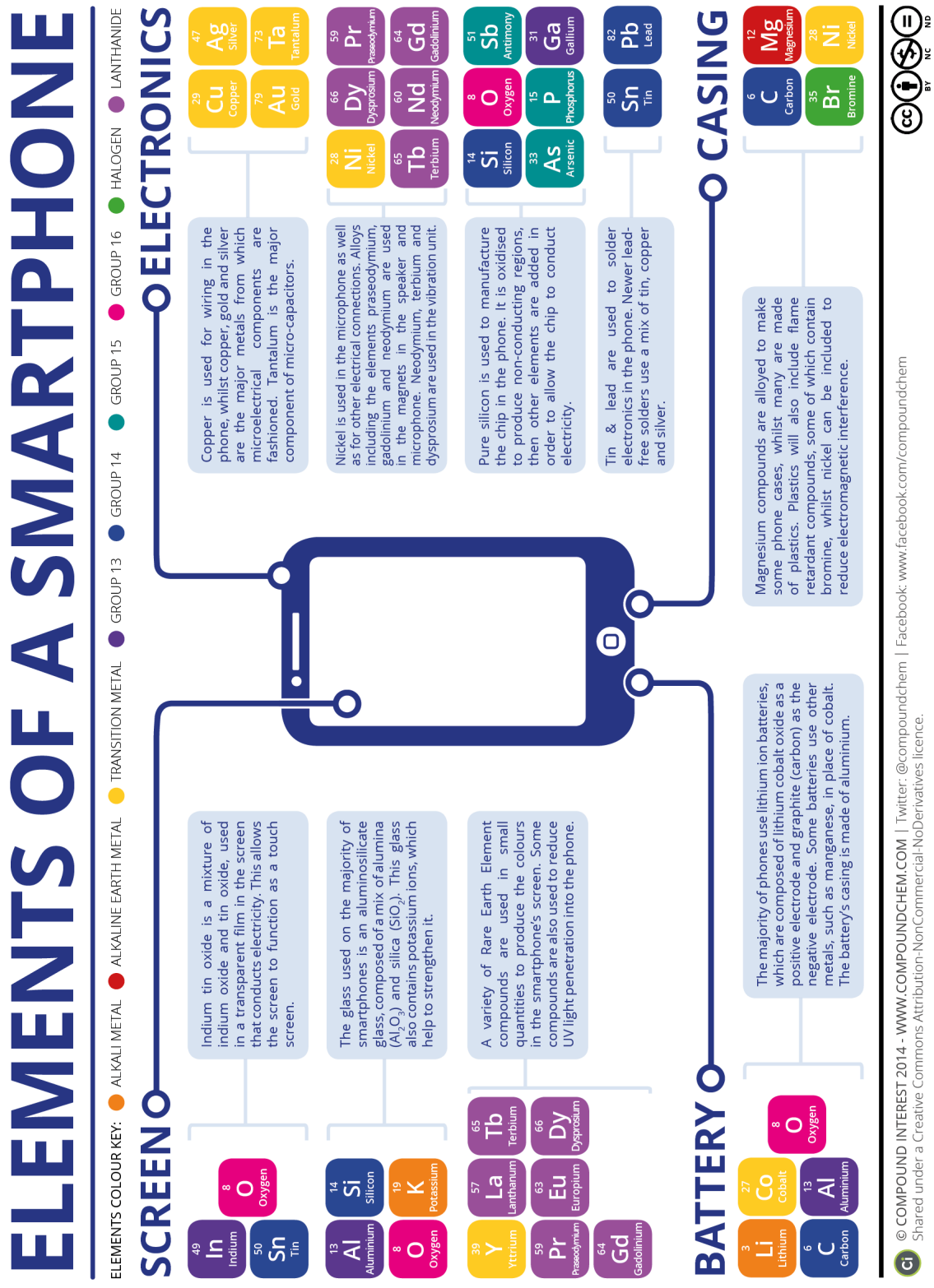
- Once each person on the team has chosen an element, have each team member circle the element on 2.D Station 2: Periodic Table of Phone Elements, 2.G Station 2: Elements of a Smartphone and 2.H Station 2: Recycling Rates of Smartphone Metals.
  Note: One set of these handouts should be shared by each team. Please discard the set of handouts used by your team when you have completed this workstation, or take the set of handouts with you.
- As a team discuss the following for each element that was chosen. Add notes for your element in 2.C. Station Reflections under Station 2 or in your notebook
  - What are the properties of that element?
  - What is its importance to the use of a cell phone?
  - Is it easy to recycle the element?
- After each person on the team has shared their information, add the following to 2.C. Station Reflections under Station 2 or in your notebook
  - Record your observations for the element you chose
  - Record two materials other than your own that you found interesting and note why you found them interesting.

2.F Station 2: Periodic Table of Mobile Phone Elements



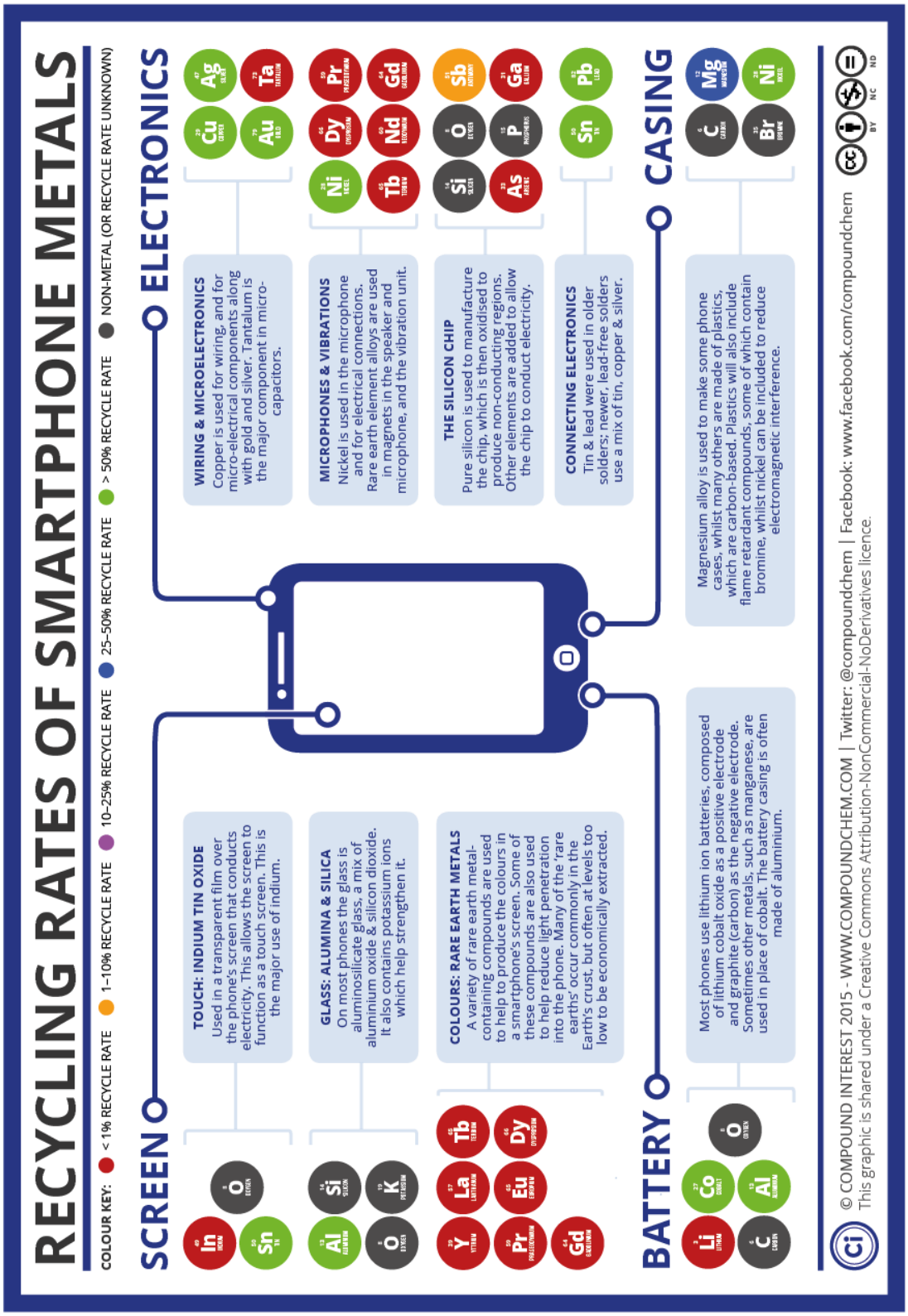
Compound Interest. (2019). *The periodic table of elements found in phones* [Information Graphic]. https://i0.wp.com/www.compoundchem.com/wp-content/uploads/2019/12/16-%E2%80%93-The-periodic-table-of-elements-found-in-phones.png?ssl=1

2.G Station 2: Elements of a Smartphone



Compound Interest. (2014). *The chemical elements of a smartphone v2* [Information Graphic]. https://i0.wp.com/www.compoundchem.com/wp-content/uploads/2014/02/The-Chemical-Elements-of-a-Smartphone-v2.png?ssl=1

2.H Station 2: Recycling Rates of Smartphone Metals



Compound Interest. (2015). *Recycling rates of smartphone elements* [Information Graphic]. https://i0.wp.com/www.compoundchem.com/wp-content/uploads/2015/09/Recycling-Rates-of-Smartphone-Elements.png?ssl=1

2.I Station 3: Exploring Microelectronic Components - Instructions (1 of 2)

Overview of Activity:
In Lesson 1, we learned that a **microchip** is a small circuit that can be used to communicate, process and store information. For this activity, it is important to understand that a microcontroller is type of microchip that functions as a tiny computer. A **microcontroller** is a compact integrated circuit typically with a processor, memory, inputs, outputs, and peripherals on a single chip. A **processor** is the brains of a microcontroller; it receives information from different components (i.e., sensors and buttons), applies the information according to the instructions (i.e. code) stored in the processor, and sends instructions back out to the components for action. **Input** is information that is received from a device or component and sent to the processor. **Output** is instruction sent from the processor and executed by a component external to the processor.

A **micro:bit** is a small, credit-card sized computer. It is a circuit board with a microcontroller, input/output peripherals and other components. The **micro:bit** can be programmed to communicate with different **input/output peripherals** like LED light displays, sensors, buttons, etc. The design and functionality of a micro:bit is similar to how a smart phone is designed with a small computer that is programmed to tell its components what to do.

This activity will explore the components of the micro:bit and identify how they simulate the functionality of cell phone components. Students will develop and share insights on the rapid evolution of technology by comparing difference versions of the mirco:bit and predicting future advances.

Individually:

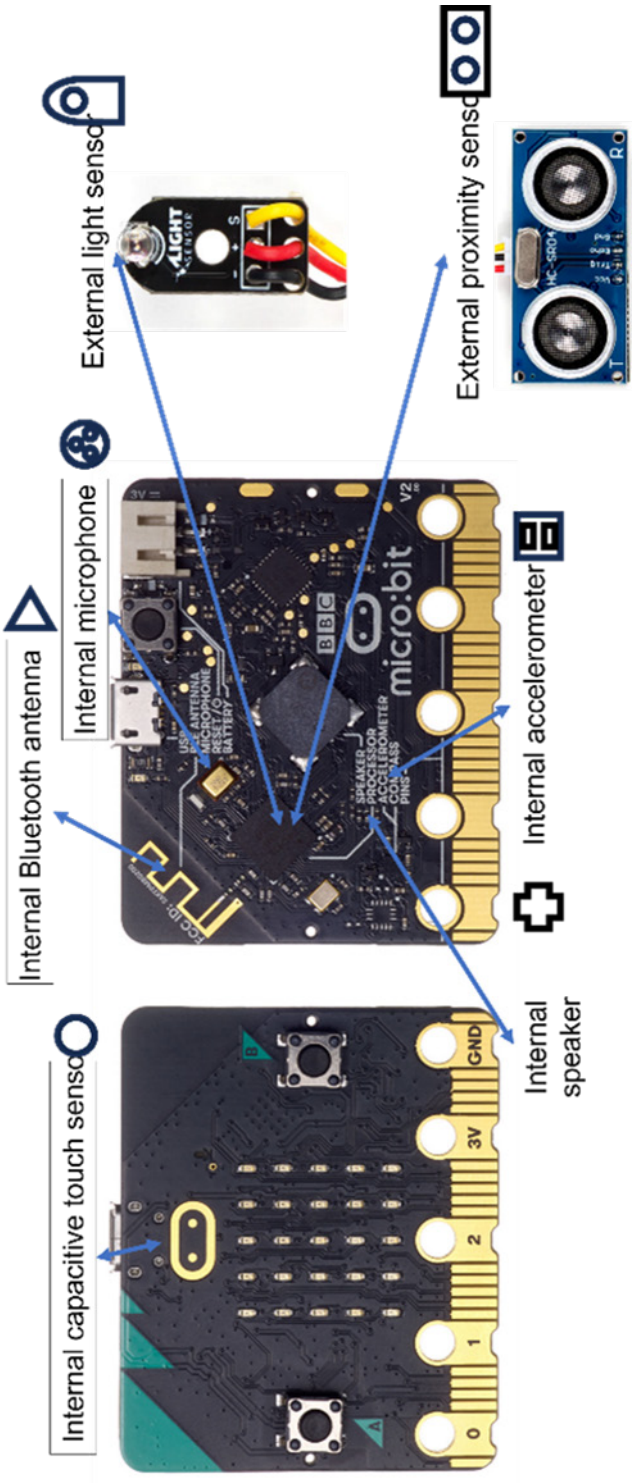
- Review 2.J Station 3 micro:bit Components Used to Simulate Cell Phone Capabilities. Identify the following and choose one to focus on:
    a. Proximity Sensor
    b. Speaker/microphone
    c. Accelerometer
    d. Light Sensor
    e. Capacitive Touch Sensor
    f. Bluetooth antenna
- Watch the video (links embedded below) associated with the component you choose. Define the functionality of your component and identify two facts you learned about your component. Write your observation on 2.C Station Reflections under Station 3 or in your notebook.
    g. For components a-d: What Sensors are in a Cell Phone
    h. For component e: How do Touchscreens Work?
    i. For component f: How Does Bluetooth work?

2.I Station 3: Exploring Microelectronic Components - Instructions (2 of 2)

As a Team:

- Share what you learned about your component from the videos.
- Discuss how the components on the micro:bit can simulate the electronics used in a cell phone. Write three observations of how the components on the micro:bit can simulate the electronics used in a cell phone on 2.C Station Reflections under Station 3 or in your notebook.
- Review 2.K Station 3: Compare micro:bit V1 & V2 Designs. Discuss the differences you observe in the detailed schematic drawings of the micro:bit boards. How do the added components in the new micro:bit (v2) increase its similarity to a cell phone? Write your observation on 2.C Station Reflections under Station 3 or in your notebook.
- (Optional) Review 2.K Station 3: Compare micro:bit V1 & V2 Specifications. Discuss the differences you observe in the specifications represented. What impact would these differences have if they were experienced in a cell phone? Write your observation on 2.C Station Reflections under Station 3 or in your notebook.
- Share observations you have about the changes in technology over the four years between the ***Original (V1)*** and ***New (V2)*** micro:bit designs? Discuss what changes might you predict for the next 5 years? 10 years? Write your observation on 2.C Station Reflections under Station 3 or in your notebook.

2.J Station 3: micro:bit Components Used to Simulate Cell Phone Capabilities

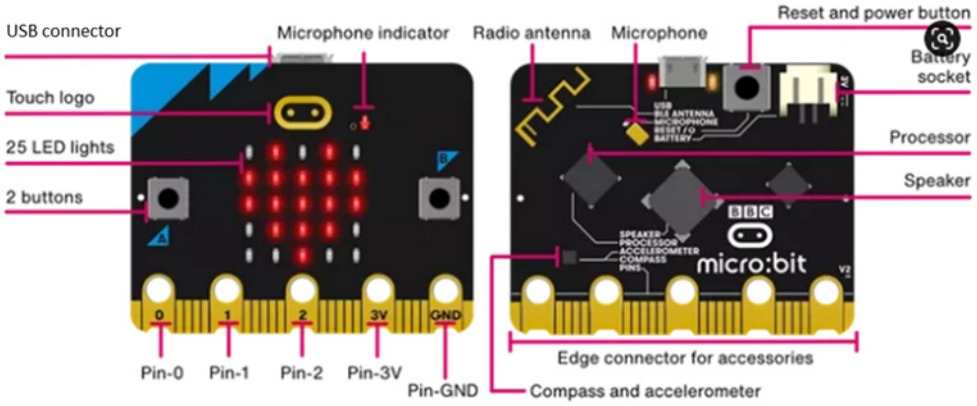


2.K Station 3: Compare micro:bit V1 & V2 Designs (1 of 2)

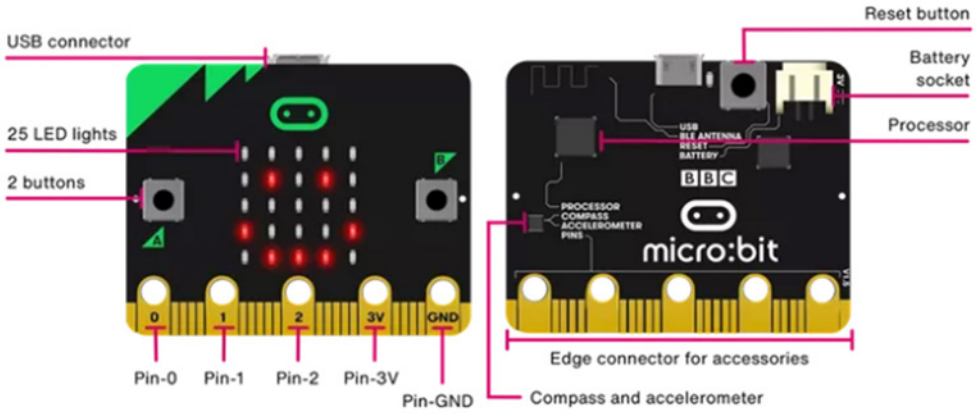
https://www.eduporium.com/micro-bit-go-v2.html?utm_source=google_shopping&utm_term=&utm_campaign=Performance+Max+(micro:bit)&utm_source=adwords&utm_medium=ppc&hsa_acc=1215712289&hsa_cam=18817986425&hsa_grp=&hsa_ad=&hsa_src=x&hsa_tgt=&hsa_kw=&hsa_mt=&hsa_net=adwords&hsa_ver=3&gad_source=1&gclid=Cj0KCQiAoKeuBhCoARIsAB4Wxtd4nDk_fEKwn412ZY7eEd6DAQSidw77NjC6Som7Na-bH3dvp3Fd_kkaAnQCEALw_wcB

The ***Original (V1)*** micro:bit was introduced in 2016. The *New (V2)* micro:bit with sound was introduced in 2020. Within four years, new technological advances were made. Review the detailed schematic drawings below and identify two or more differences.

New micro:bit with sound



Original micro:bit



2.K Station 3: (Optional) Compare micro:bit V1 & V2 Specifications (2 of 2)

https://coolcomponents.co.uk/blogs/news/comparing-the-bbc-micro-bit-v1-and-v2-what-is-different
The ***original (v1)*** micro:bit was introduced in 2016. The ***new (v2)*** micro:bit was introduced in 2020. Within four years, new technological advances were made. Review the specifications below and identify two or more differences.

Item	V1	V2
Processors and Memory		
Processor	Nordic nRF51822	Nordic nRF52833
Flash Memory	256kB Flash	512KB
RAM	16kB RAM	128KB
Speed	16MHz	64MHz
Communication		
Bluetooth	Bluetooth 4.0	Bluetooth 5.1 with Bluetooth Low Energy(BLE)
Radio Communication	2.4GHz Micro:bit Radio (80 channels)	2.4 GHz Micro:bit Radio (80 channels)
Input Devices		
Buttons	2 Programmable (A & B), 1 System (Reset)	2 Programmable (A & B), 1 System (Power/Reset)
On/Off Switch	None	Press and hold rear power button
Touchpad	None	Touch sensitive logo
Microphone	None	Onboard Knowles SPU0410LR5H-QB-7 MEMS microphone (with LED indication)

2.L Client Letter #2

Dear Students,

Thank you for working with me broaden my knowledge about the field of microelectronics. So far you have helped me understand how you use microelectronics in your daily life, gain a basic understanding of the field of microelectronics, and understand how a product starts as a natural resource and ends up as a device in a store. These terrific insights have sparked more questions that I could use your help answering.

I am interested in learning more about the specific elements used to make microelectronic components, what happens to those materials after the electronic device is no longer used, and anything you can learn that would help me understand the rapid evolution of microelectronics.

Specifically, I would like your help in researching the following:

- Estimate your usage of cell phones and tablets. Describe what happens after these devices are obsolete.
- Identify elements used in a cell phone. Explain why these elements are important to the functionality of a cell phone and their rate of recycle.
- Develop an understanding of microelectronic components along with their functionality and generate insights on the rapid evolution of microelectronics.

I am very interested in what your research will bring to light. All of this information will help my company better support our clients interested in jobs in microelectronics.

Sincerely,

Sam Springs

Sam Springs
Career Consultant
Jumpstart Jobs

2.M Vocabulary

Station 1: Microelectronics Usage and Lifecycle

- microelectronics – the design manufacture and use of microchips
- obsolescence – the condition of no longer being used or useful
- product lifecycle – a period of time from when a product is introduced until it is removed from use
- e-waste – discarded electrical or electronic products
- recycle – to break something down into new raw material that can reused to make different product.
- upcycle - to repurpose or reuse something for a different function

Station 2: Microelectronic Materials

- element – in chemistry, refers to a substance that cannot be broken down into smaller parts or changed into another substance
- properties – in chemistry, unique characteristics used to identify an element

Station 3: Exploring Microelectronic Components

- micro:bit – is a small credit card sized computer. It is a circuit board with a microcontroller, inputs, outputs, and other components
- microchip: tiny circuits that exist in many electronic devices, allowing the devices to communicate, store, and process information.
- microcontroller - a specific type of microchip that functions as a tiny computer. A microcontroller is a compact integrated circuit typically with a processor, memory and input/output peripherals on a single chip.
- processor – the brains of a microcontroller; it receives information from different components (i.e.sensors, buttons, etc), applies the information according to the instructions (i.e. code) stored in the processor, sends output instructions back to specific components for action.
- input/output peripherals – interface the processor with the outside world (I.e., buttons, sensors, lights)
- input - information that is received from a device or components and sent to the processor
- output - instruction sent from the processor and executed by a component external to the processor

LESSON THREE:

Lesson Objectives
Students will be able to:
- Explore various careers related to the field of ME
- Gain insights into the roles, skills, and educational paths required for ME related jobs

Time Required
Three 50 min class periods

Standards Addressed
PCC-2.1 Determine roles, functions, education, and training requirements of various career options within one or more career clusters and pathways

PCC-2.2 Analyze career trends, options and opportunities for employment and entrepreneurial endeavors for selected career clusters and pathways

PCC-2.3 Evaluate selected careers and pathways for education requirements, working conditions, benefits, and opportunities for growth and change

PCC-2.4 Use appropriate technology and resources to research and organize information about careers

Key Terms
ME-related careers

Lesson Summary
This lesson asks students conduct research on various microelectronics related careers and aims to increase students' interest in pursuing a career in this field.

Teacher Background
ME related careers
- Electrical engineering
- Advance manufacturing and materials
- https://careers.semi.org/career-explorer?tab=careers

Vocabulary
Microelectronics
- https://www.anl.gov/science-101/microelectronics

Before the Activity
View the videos about ME-related careers

Classroom Instruction
Introduction
1. **Begin with a brief discussion on the importance of ME in everyday life.** Remind students that ME involves design and manufacture of small electronic devices and components.
2. **Ask students if they are familiar with any microelectronics-related careers such as electrical engineer, semiconductor technician, software engineer, systems engineer.**
3. **Share real-life examples and success stories in ME.** If time allows, consider showing one or both of these videos.
   - Chip in: Leading edge (11:00-23:00)
   - Chip in: Making micro (1:50-22:25)

   Possible discussion questions you could us:
   - *What did you notice or learn about careers in the semiconductor industry?*
   - *What did you learn about how microchips help make the world run?*
   - *How would you use microelectronics to make the world a better place?*
   - *What are some of the benefits of working in the microchip industry? What are some challenges to breaking into it?*
   - *Which person's story did you connect to the most? Why?*
   - *What part of the roadtrippers' stories did you connect to the most? Why?*
   - *Is there anything you'd like to learn more about when it comes to microelectronics?*

4. **Facilitate a class discussion on the skills and qualifications needed for ME related careers.**
5. **Express the importance of STEM education and future career opportunities in ME.** Tell students that they will learn more about ME related careers by researching different careers in ME.

Activity

6. **Provide students with a list of ME-related careers (3.A).** This list can be expanded. Ask students to work in small groups of three. Instruct each group to choose three ME related careers from the list for research. Allow time for students to choose three careers that they are interested in exploring.
7. **Share the career survey hand out with students (3.B) and have students in their small groups answer the questions on the career survey based on what they think about each chosen career.**
8. **Allocate time for research.** Encourage students to explore credible sources. For students who need more guidance and help in finding resources, provide the link: https://careers.semi.org/home
   Have students click on the Explore Careers tab at the top of the home page. Students will find careers such as engineer, information technology, manufacturing and production, marketing, business management and operations, and sales.
9. **Have each group present a brief overview of the ME-related career they researched.** During their presentations, groups should respond to the following questions:
   - *What is the biggest similarity between your initial thoughts and what you learned about these careers from the research?*
   - *What is the biggest difference between your initial thoughts and what you learned about these careers from the research?*
   - *Based on what you learned about the duties of these jobs, why do you think these jobs are important?*
   - *Based on what you learned, how do you think these jobs help other people or society?*
   - *Would you be interested in doing a job like one of these in the future? Why or why not?*

Closure

10. **Facilitate a discussion on what they learned about potential careers in the field. A**sk questions about the commonalities and differences between careers. Encourage students to continue exploring ME-related careers and consider pursuing careers in ME-related fields.

Lesson Materials

Per classroom
- Laptops for each student

Per Group (3 per group)
- 3 Laptops

Per Student
- 1 Laptop
- Copy of 3.A List of ME Careers and 3.B Career Survey

Duplication Masters

3.A List of ME Careers
3.B Career Survey

Educator Resources

See links for career videos

Assessment

Activity Embedded Assessment
Research and Presentations

3.A List of ME-related Careers

- Electronics engineering technician
- Electrical engineer
- Environmental engineer
- Aerospace engineer
- Broadcast engineer
- Robotics engineer
- Mechanical engineer
- Materials engineer
- System engineer
- Physicist
- Chemist
- Patent attorney
- Law firm technology consultant
- Software developer
- Litigation support attorney
- Data scientist
- Process engineer
- Semiconductor manufacturing technician
- Integrated circuit designer
- Field service engineer
- Sales and marketing
- Applications engineer
- Supply chain and operations engineer
- Quality and reliability engineer
- Research and development engineer
- Information technology engineer
- Integration and yield engineer
- Computer scientist
- Computer engineer
- Wafer fab technicians
- Wafer fab operators
- Semiconductor process technician
- Equipment maintenance technician
- Process integration technician
- Analytical lab technician
- Machinist

Name_____ Date_____ Period _____

3.B Career Survey

Career One: _____

1. What is required for the job? What kind of schooling? Training? Work experience?

2. What is the starting salary?

3. What are the possibilities for advancement?

4. How many hours/days of work are typical?

5. What are the rewards of the job?

6. What are the drawbacks?

7. Rank the career based on the following:
    a. Fits my desire for money 1 2 3 4 5 6 7 8 9 10
    b. Fits my desire for family 1 2 3 4 5 6 7 8 9 10
    c. Fits my desire for location 1 2 3 4 5 6 7 8 9 10
    d. Fits my desire for lifestyle 1 2 3 4 5 6 7 8 9 10

Name_____ Date_____ Period _____

3.B Career Survey

Career Two: _____

1. What is required for the job? What kind of schooling? Training? Work experience?

2. What is the starting salary?

3. What are the possibilities for advancement?

4. How many hours/days of work are typical?

5. What are the rewards of the job?

6. What are the drawbacks?

7. Rank the career based on the following:
    a. Fits my desire for money 1 2 3 4 5 6 7 8 9 10
    b. Fits my desire for family 1 2 3 4 5 6 7 8 9 10
    c. Fits my desire for location 1 2 3 4 5 6 7 8 9 10
    d. Fits my desire for lifestyle 1 2 3 4 5 6 7 8 9 10

Name_____ Date_____ Period _____

3.B Career Survey

Career Three: _____

1. What is required for the job? What kind of schooling? Training? Work experience?

2. What is the starting salary?

3. What are the possibilities for advancement?

4. How many hours/days of work are typical?

5. What are the rewards of the job?

6. What are the drawbacks?

7. Rank the career based on the following:
    a. Fits my desire for money 1 2 3 4 5 6 7 8 9 10
    b. Fits my desire for family 1 2 3 4 5 6 7 8 9 10
    c. Fits my desire for location 1 2 3 4 5 6 7 8 9 10
    d. Fits my desire for lifestyle 1 2 3 4 5 6 7 8 9 10

LESSON FOUR:

Lesson Objectives
Students will be able to:
- Research and present information around the ethics of microelectronics
- Communicate their chosen roles and contributions during the interactive classroom simulation.
- Demonstrate teamwork and cooperation while working together to develop their case
- Gain an understanding of various career connections within the microelectronic industry and their legal and ethical implications.

Time Required
Two to three 50-minute class periods

Standards Addressed
PCC-6.3 Social and Cross-Cultural Skills
- Interact effectively with others in a respectable, professional manner
- Respect cultural differences and work effectively with people from a range of social and cultural backgrounds
- Respond open-mindedly to different ideas and values
- Leverage social and cultural differences to create new ideas and increase both innovation and quality of work

Lesson Summary
Students will critically analyze and present arguments for and against microelectronics technology, considering ethical, social, economic, and environmental perspectives. They will engage in a courtroom-style debate to defend their positions as either proponents or opponents of microelectronics.

Teacher Background
Topic 1: Trial Proceedings
Teacher should have general knowledge of trial proceedings to stage the “courtroom”.
- The Trial Process
- How Courts Work

Topic 2: Microelectronic Ethics
Microelectronics Ethics
- Trust Issues in Microelectronics: The Concerns and the Countermeasures
- Building Trust in Microelectronics: A Comprehensive Review of Current Techniques and Adoption Challenges

Topic 3: Career Connections
Career Connections
- 8 Attractive Jobs for Lawyers in the Legal Tech Industry

Vocabulary
Trial proceedings, microelectronics ethics

Before the Activity
Divide the class into two groups: Proponents and Opponents of microelectronics. (4.A)
Note: You can pre-assign students or let students choose based on their current opinions.

Classroom Instruction

Introduction

1. **Ask students their ideas of ethics around microelectronics (potentially explain what ethics are).** Maybe include a current event, one pro-microelectronics, and one con-microelectronics. Have a class discussion around the ethical implications of both.
2. **Introduce the career connections of a patent attorney, law firm technology consultant, legal software developer, intellectual property attorney, litigation support attorney, business lawyer, corporate counsel, legal content writer.** Some students might already research these jobs as part of Lesson 3. If not, spend a day exploring the career connections as well as the jobs of the people in the courtroom, this can allow students to self-select their roles for the activity, or send you the role they would like to have and then the teacher assigns the students roles (reference duplication master 4.B).
   Some resources students could use:
   https://www.careeronestop.org/
   https://www.bls.gov/k12/students/careers/career-exploration.htm
3. **Explain the purpose of the activity: to explore the ethical considerations surrounding microelectronics technology through a courtroom debate.** Discuss the importance of understanding both sides of an issue and the skills required for effective argumentation.
4. **Divide the class into two groups: Proponents and Opponents of microelectronics.** Assign specific roles within each group: lawyers, expert witnesses, and researchers. Distribute index cards with assigned roles to each student.
5. **Provide time for students to conduct research on their assigned positions.** Encourage them to explore various sources.
6. **In their respective groups, students discuss their findings and strategize arguments.** Lawyers prepare opening statements, cross-examination questions, and closing arguments. Expert witnesses gather evidence and prepare to present key points supporting their positions.

PCC-6.4 Productivity and Accountability Demonstrate additional attributes associated with producing high quality products including the abilities to:

- Work positively and ethically
- Manage time and projects effectively
- Participate actively, as well as be reliable and punctual
- Present oneself professionally and with proper etiquette
- Collaborate and cooperate effectively in teams
- Be accountable for results

PCC-7.4 Demonstrate standards of legal and ethical behavior in human, cultural, and societal issues related to technology and digital citizenship

Key Terms

Microelectronics, ethics, trial, courtroom

Lesson Materials

Per classroom

- Laptops for each student
- index cards (optional)

Per Group (3 per group)

- 3 Laptops
- 3 index cards (optional)

Per Student

- 1 Laptop
- 1 index card (optional)

Duplication Masters

4.A, 4.B, 4.B Answer Key

LESSON FOUR:

Educator Resources
Laptop, Index card (optional)

Assessment

Pre-Activity Assessment
Ask students:
What are ethics?

What are the ethical issues around microelectronics?

How do you feel about exploring the legal and ethical implications of careers in the microelectronic industry? Are there any specific topics or questions you're interested in learning more about?

Have students anonymously send questions about any vocabulary that is confusing (maybe spend a day going over some jargon that might be advanced and break it down or create a word in place that the students can use, can be done on a Google form or a Microsoft from).

Activity Embedded Assessment
Students are engaging in a courtroom like debate, half of the class is pro-electronics, half of the class is con-microelectronics. Students will be researching and presenting their findings to a judge (could be the teacher, or a student, or a teacher from a different class) and a jury (could be students, could be other teachers, or another class).

Activity

7. **Courtroom Setup:** Arrange the classroom furniture to mimic a courtroom setting, with one side for the Proponents and the other for the Opponents. Designate areas for the judge (the teacher), jury (if applicable, could be another class or some teachers), lawyers, and witnesses.
8. **Opening Statements:** Each group's lawyers present compelling opening statements, outlining their arguments and setting the stage for the debate.
9. **Witness Testimonies:** Expert witnesses from both sides present their testimonies, supported by evidence and research. Lawyers conduct cross-examinations, challenging the credibility and validity of opposing witnesses' arguments.
10. **Rebuttal and Cross-Examination:** Lawyers offer rebuttals to counter opposing arguments and raise new points in support of their positions. Cross-examination continues as lawyers challenge each other's witnesses and evidence.
11. **Closing Arguments:** Lawyers deliver powerful closing arguments, summarizing key points and persuading the judge and jury to favor their side.
12. **Deliberation and Verdict:** If time allows, facilitate a brief deliberation among the judge and jury. The judge (or teacher) announces the verdict based on the arguments presented.

Closure

13. **Have students write a reflective paper (around 5-10 minutes) on their experiences preparing for and participating in the debate,** highlighting any shifts in their perspectives and insights gained AND/OR facilitate a class discussion exploring the broader implications of microelectronics technology and the ethical dilemmas raised during the debate.

Ethics – Make Your Case

Post-Activity Assessment: Have students respond to a reflective prompt (around 5-10 minutes) on their experiences preparing for and participating in the debate, highlighting any shifts in their perspectives and insights gained AND/OR facilitate a class discussion exploring the broader implications of microelectronics technology and the ethical dilemmas raised during the debate.

1. What legal and ethical issues did you encounter in your chosen role during the classroom activity?
2. How did your role contribute to the resolution of the legal case?
3. What skills were important for fulfilling your responsibilities in the simulation?
4. How do you think the work of professionals in the microelectronic industry intersects with the legal field?
5. What are some ways that technology can be used to address legal and ethical challenges in the microelectronic industry?

Assess students based on their participation, preparation, argumentation skills, use of evidence, and ability to engage respectfully with opposing viewpoints.

Use a rubric to evaluate individual and group performance, focusing on content, organization, delivery, and persuasion.

4.A Make Your Case

Instructions: You will be participating in a courtroom-style debate on the topic of microelectronics. Half of the class will represent the Pro-Microelectronics side, while the other half will represent the Con-Microelectronics side. Follow the prompts below to prepare for your role in the debate.

Pro-Microelectronics: [List of students assigned to this side]
Con-Microelectronics: [List of students assigned to this side]

Preparation:

1. **Research:** Conduct research to understand the arguments supporting your assigned position on microelectronics. Gather evidence, statistics, case studies, and expert opinions to support your arguments.
2. **Argument Development:** Develop key arguments to support your position on microelectronics. Consider ethical, social, economic, and environmental factors in your arguments.
3. **Evidence Gathering:** Identify specific examples and evidence to reinforce your arguments during the debate. Prepare to present your evidence convincingly to support your position.
4. **Counterarguments:** Anticipate potential counterarguments from the opposing side. Prepare rebuttals and responses to effectively counter opposing arguments.

Debate Structure:

1. **Opening Statements:** Each side will have [insert time limit] to present their opening statements. Focus on introducing your position and outlining your main arguments.
2. **Presentation of Evidence:** Each side will present evidence to support their arguments. Use specific examples, data, and expert testimony to strengthen your case.
3. **Cross-Examination:** Lawyers will have the opportunity to cross-examine witnesses from the opposing side. Prepare questions to challenge the credibility and validity of the opposing side's arguments and evidence.
4. **Rebuttals:** Following the presentation of evidence, each side will have [insert time limit] for rebuttals. Address any weaknesses in the opposing side's arguments and reinforce your own position.
5. **Closing Arguments:** Each side will have [insert time limit] to deliver closing arguments. Summarize your main points and make a final appeal to the judge (and jury, if applicable) to support your position.

Name_____ Date_____ Period _____

4.B Oh the places we can go: Exploring Jobs in the Microelectronic Industry - Optional

Instructions: Research the following career connections in the microelectronic industry. Explore the roles and responsibilities of each profession. Reflect on the legal and ethical implications associated with these careers. Choose a role that interests you for an interactive classroom activity and turn in the worksheet.

1. **Patent Attorney**
   Role Description:

   Responsibilities:

   Legal and Ethical Implications:

2. **Law Firm Technology Consultant**
   Role Description:

   Responsibilities:

   Legal and Ethical Implications:

3. **Legal Software Developer**
   Role Description:

   Responsibilities:

   Legal and Ethical Implications:

4. **Intellectual Property Attorney**
   Role Description:

   Responsibilities:

   Legal and Ethical Implications:

5. **Litigation Support Attorney**
   Role Description:

   Responsibilities:

   Legal and Ethical Implications:

Name_____ Date_____ Period _____

4.B Oh the places we can go: Exploring Jobs in the Microelectronic Industry - Optional

6. **Business Lawyer**
   Role Description:

   Responsibilities:

   Legal and Ethical Implications:

7. **Corporate Counsel**
   Role Description:

   Responsibilities:

   Legal and Ethical Implications:

8. **Legal Content Writer**
   Role Description:

   Responsibilities:

   Legal and Ethical Implications:

4.B Oh the places we can go: Exploring Jobs in the Microelectronic Industry (ANSWER KEY)

1. **Patent Attorney**
   Role Description: Patent attorneys specialize in intellectual property law, particularly patents. They assist inventors and companies in securing patents for their inventions.

   Responsibilities:
   - Conducting patent searches
   - Drafting patent applications
   - Providing legal advice on patent infringement issues

   Legal and Ethical Implications:
   - Ensuring fair protection of intellectual property rights
   - Balancing innovation with the public's interest in access to knowledge

2. **Law Firm Technology Consultant**
   Role Description: Law firm technology consultants help law firms integrate technology into their practices to improve efficiency and effectiveness.

   Responsibilities:
   - Assessing technology needs
   - Recommending and implementing software solutions
   - Providing training and support to legal professionals

   Legal and Ethical Implications:
   - Safeguarding client confidentiality and data security
   - Ensuring compliance with legal and ethical standards in technology use

3. **Legal Software Developer**
   Role Description: Legal software developers design and create software solutions tailored to the needs of legal professionals, such as case management systems and document automation tools.

   Responsibilities:
   - Collaborating with lawyers to understand their requirements
   - Writing code and testing software
   - Providing ongoing support and updates

   Legal and Ethical Implications:
   - Ensuring the accuracy and reliability of legal software
   - Protecting client data and privacy within software applications

4.B Oh the places we can go: Exploring Jobs in the Microelectronic Industry (ANSWER KEY)

4. **Intellectual Property Attorney**
   Role Description: Intellectual property attorneys specialize in protecting intangible assets such as patents, trademarks, and copyrights.

   Responsibilities:
   - Advising clients on intellectual property rights
   - Filing trademark and copyright applications
   - Handling disputes related to intellectual property infringement

   Legal and Ethical Implications:
   - Balancing the rights of creators with the public interest in accessing information and innovation
   - Addressing issues of piracy and counterfeiting in the digital age

5. **Litigation Support Attorney**
   Role Description: Litigation support attorneys assist in the preparation of legal cases by managing and analyzing large volumes of electronic data.

   Responsibilities:
   - Collecting and organizing electronic evidence
   - Conducting electronic discovery
   - Collaborating with trial teams to develop case strategies

   Legal and Ethical Implications:
   - Ensuring the integrity and admissibility of electronic evidence
   - Protecting sensitive information during the discovery process

6. **Business Lawyer**
   Role Description: Business lawyers advise companies on a wide range of legal issues related to business operations and transactions.

   Responsibilities:
   - Drafting and reviewing contracts
   - Providing guidance on corporate governance
   - Assisting with mergers and acquisitions

   Legal and Ethical Implications:
   - Promoting transparency and accountability in business practices
   - Addressing conflicts of interest and ethical dilemmas in corporate settings

4.B Oh the places we can go: Exploring Jobs in the Microelectronic Industry (ANSWER KEY)

7. **Corporate Counsel**
   Role Description: Corporate counsel are lawyers who work directly for corporations, providing legal advice and representation on internal matters.

   Responsibilities:
   - Advising company executives on legal risks and compliance issues
   - Drafting and negotiating contracts
   - Representing the company in legal disputes

   Legal and Ethical Implications:
   - Balancing the interests of the company with legal and ethical standards
   - Upholding professional integrity while serving as an advocate for the organization

8. **Legal Content Writer**
   Role Description: Legal content writers create written materials for law firms, legal publications, and online platforms, such as articles, blog posts, and educational resources.

   Responsibilities:
   - Researching legal topics and developments
   - Writing clear and informative content
   - Ensuring accuracy and adherence to legal standards

   Legal and Ethical Implications:
   - Providing reliable and trustworthy information to the public
   - Avoiding plagiarism and respecting copyright laws