A Practical Guide to E-waste Education and Events in Schools

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Key Vocabulary and Definitions

Term	Definition	Source
Battery	A device that stores and releases electrical energy. Batteries come in various types, such as single use (e.g., AA, AAA) and rechargeable (e.g., lithium-ion).	https://www.energy.gov/science/doe-explainsbatteries
Conductor	A material that allows the flow of electrical current in one or more directions.	https://www.nde-ed.org/Physics/Electricity/resistance.xhtml
Critical Materials	Any non-fuel mineral, element, substance, or material that the Secretary of Energy determines (i) has a high risk of supply chain disruption; and (ii) serves an essential function in one or more energy technologies, including technologies that produce, transmit, store, and conserve energy.	https://www.energy.gov/cmm/what-are-critical-materials-and-critical-minerals
E-waste	Waste consisting of discarded electronic products (such as computers, televisions, and cell phones).	https://www.merriam-webster.com/dictionary/e-waste
Electrode	A conductor through which electricity enters or leaves an object, substance, or region.	https://www.britannica.com/science/electrode
Electrolyte	A liquid or gel that that transfers ions between the anode and cathode in a battery.	https://www.energy.gov/science/doe-explainsbatteries
Electronics	Devices that use electricity to perform tasks, such as phones, laptops, and game consoles.	https://www.merriam-webster.com
Insulator	A material that does not easily allow the flow of electricity.	https://www.nde-ed.org/Physics/Electricity/resistance.xhtml
Landfill	A site for the disposal of waste materials by burial. E-waste should not be disposed of in landfills due to the harmful materials it contains.	https://www.epa.gov
Product Life Cycle	The stages a product goes through from creation to disposal or recycling.	https://www.epa.gov/electronics-batteries-management/electronics-basic-information-research-and-initiatives
Recycle	The process of converting waste into reusable material. Recycling e-waste helps recover valuable materials and prevents pollution.	https://www.sciencedirect.com/topics/earth-and-planetary-sciences/reduce-reuse-and-recycle
Refurbish	The action of renovating and restoring an electronic device to make it functional again.	https://dictionary.cambridge.org
Repair	To restore by replacing a part or putting together what is torn or broken.	https://www.merriam-webster.com/dictionary/repair
Reuse	To use again especially in a different way or after reclaiming or reprocessing.	https://www.sciencedirect.com/topics/earth-and-planetary-sciences/reduce-reuse-and-recycle

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SECTION 1. HANDBOOK OVERVIEW

HANDBOOK OVERVIEW

The Practical Guide to E-waste Education and Events in Schools is a comprehensive resource that equips educators and outreach professionals to deliver impactful lessons on electronic waste (e-waste), critical materials, and battery recycling while launching effective school-based e-waste recycling programs. It offers step-by-step guidance for starting and managing e-waste education efforts, including tips on student engagement, engaging recycling partners, planning collection logistics, creating promotional materials, and overcoming common challenges. The guide also supports curriculum development and scaling initiatives across schools to foster lasting recycling habits.

The guide focuses on four key objectives:

1. **Science, Technology, Engineering, and Mathematics (STEM) Learning Through E-waste***: Introduce K–12 students to energy, batteries, critical materials, and the environmental impact of electronic waste, while encouraging sustainable habits early on.*
2. **School Partnerships***: Guide schools and e-recycling companies to collaborate and deliver e-waste education and organize collection events that engage students and their communities.*
3. **Scalable Program Design***: Provide a flexible framework that schools and e-recycling companies can adapt and replicate to expand e-waste education and recycling efforts across different settings.*
4. **Hands-on Engagement***: Teach the use of interactive e-waste activities, like laptop disassembly demos, games, and outreach events to make learning about e-waste tangible and memorable.*

This handbook is a product of the project titled "Comparing Strategies to Collect Battery-Containing Devices in States with and without Electronics Recycling Laws," created by Battelle Energy Alliance, LLC under Contract No. DE-AC07-05ID14517 with the U.S. Department of Energy. It demonstrates a broader commitment to enhancing electronic waste recycling awareness and sharing the importance of recycling critical materials through community-focused education and outreach.

This handbook is organized as follows:

- **Section 1:** Handbook Overview
- **Section 2:** Curriculum and Presentation Overview
- **Section 3:** E-waste Hands-on Activity Lesson Plans
- **Section 4:** Planning E-waste Collection at Schools
- **Appendix:** Posters, Handouts, and Planning Resources

1.1 Curriculum Overview: E-waste Recycling Project

The curriculum in Section 2 introduces students to key concepts in electronics, batteries, e-waste, and critical materials through hands-on, age-appropriate STEM activities. Younger students explore what qualifies as an electronic device and how batteries work through experiments like Energy Sticks and Lemon Batteries. They also learn what e-waste is, how it differs from general recycling, and why proper disposal matters, reinforced by the E-waste Sorting Game. Middle and high school students dive deeper into the product life cycle and the importance of recovering critical materials. High schoolers also participate in laptop disassembly to examine battery lifespan and internal components. To reinforce learning, older students engage in interactive games such as E-waste Trivia, Tic-Tac-Toe, Critical Material Fishing, and Electronic Bingo. The curriculum concludes with a focus on the environmental and health risks of improper e-waste disposal, highlighting the dangers of toxic substances and their impact on ecosystems and human health.

Table 1 provides an overview of the appropriate grade-level core concepts, topic progression, and hands-on activities and demos that are covered in further detail in Section 2. In addition to the activities performed in a classroom and assembly presentation presented in Table 1, Section 3 includes an e-waste bingo and a critical material fishing game, which are great for school or a community fair setting. The outreach materials supply checklist shown in Table 4.

Table 1. E-waste curriculum presentation activities by grade level.

Topic	Elementary School	Middle School	High School	Activities/Demonstrations
What is an electronic?	x	x		Electronic waste (e-waste) demonstration
How does battery work?	x	x		Energy sticks/lemon battery
What is e-waste?	x	x	x	E-waste sorting game
Product life cycle and critical materials		x	x	Critical materials review
Laptop disassembly and battery lifespan			x	Laptop disassembly
E-waste discussion			x	E-waste Kahoot/trivia
		x		E-waste tic-tac-toe

1.2 Outreach Formats and Setups

A successful e-waste education and recycling program begins with identifying and planning for your audience. In K–12 settings, your audience includes students, educators, school staff, and families. Tailoring your outreach to the age group, school environment, and communication preferences of your audience will help ensure meaningful engagement and participation.

To support schools in preparing for these events, here are key considerations and planning tips for each outreach format:

- Ensure convenient drop-off locations and hours for e-waste collection
- Provide clear steps for best data security practices for donated devices
- Explain responsible recycling practices and environmental impacts
- Provide educational value and alignment with school learning goals.

Through planning and focusing on the objectives and audience expectations, K-12 schools can successfully implement an e-waste recycling program that not only promotes environmental sustainability but also educates and involves the entire school community in responsible recycling practices.

The guide supports four outreach formats: (1) large presentations, (2) classroom lessons, (3) mini fairs, and (4) community events. Each is adaptable to different group sizes and settings. Activities align with the curriculum in Section 2 and are detailed in Section 3. The following sections outline the four outreach formats, providing suggestions for audience size, setting, duration, and other key considerations.

1.2.1 Large Group Presentations (Assemblies)

Audience: 40–300 students
Setting: Gym or auditorium (shown in Figure 1)
Duration: 30–45 minutes

Key Considerations:

- ☑ Confirm availability of audiovisual (AV) equipment (e.g., screen, projector, speakers, power, adapters)
- ☑ Bring printed posters as a backup in case of tech failure
- ☑ Prepare slides aligned with suggested pacing (see Table 2 or Section 2)
- ☑ Plan and gather materials for interactive elements (e.g., energy sticks, sorting game)
- ☑ Coordinate with school staff on timing and space setup

Table 2. Example for elementary large-presentation pacing.

Time (30)	Time (45)	Topic	Lecture Aid	Guiding Questions/Activities
9 min	14 min	Electronics	Slide or e-waste poster	• What is an electronic device? • What are some common electronics you would find in your home (e.g., living room, kitchen, bathroom)?
8 min	12 min	Battery Basics	Slide or battery poster	• How many battery types are there? • What is an example of an automotive battery not used in cars or trucks? Activity: Energy sticks (2–4 volunteers)
9 min	14 min	E-waste and Recycling	Slide or recycling poster	• What do we do with e-waste? • What devices from your home can be recycled? Activity: Sorting game (10 volunteers)
4 min	5 min	Q&A and Wrap-up	Handouts, stickers (optional)	Activity: Open Q&A session and begin optional distribution of handouts or stickers

1.2.2 Classroom Presentation

Audience: 10–45 students
Setting: Standard classroom
Duration: 30–45 minutes

Key Considerations:

- ☑ Align content with grade-level curriculum (see Section 2)
- ☑ Incorporate hands-on demos (e.g., lemon battery, energy stick)
- ☑ Allow time for question and answer (Q&A) and discussion
- ☑ Adjust pacing for smaller group engagement
- ☑ Consider smaller posters for space considerations

Figure 1. Pictures of large-presentation set up: (A) set up in the gym with 3 educational posters and presentation and (B) set up showing students sitting in front of the presenter.

1.2.3 E-waste Mini-Fairs

Audience: 20–60 students rotating through stations
Setting: Gym, cafeteria, or large open space (Figure 1)
Duration: 45–60 minutes (Table 3)

Key Considerations:

- ☑ Set up 3–5 stations with posters, demos, and materials (Figure 2)
- ☑ Assign a timekeeper to manage station rotations (~8–10 minutes each)
- ☑ Prepare signage and group numbers for smooth transitions
- ☑ Include a brief intro and closing presentation
- ☑ Ensure enough volunteers to staff each station

Table 3. Example e-waste mini-fair agenda.

Time Duration	Activity
15 min	**Setup** – Tables, posters, projector, materials
15 min	**Welcome and Intro Presentation** – Brief overview of e-waste and what students will do
3 min	**Group Assignment** – Divide students into 4 groups (G1–G4)
15 min	**Station Rotations** – Each group visits 4 stations, 8 minutes per station
3 min	**Re-group** – Gather students back together
5 min	**Wrap-up Presentation** – Recap key takeaways
10 min	**Q&A and Handouts** – Optional stickers, flyers, or giveaways
15 min	**Clean-up** – Pack up materials and reset space

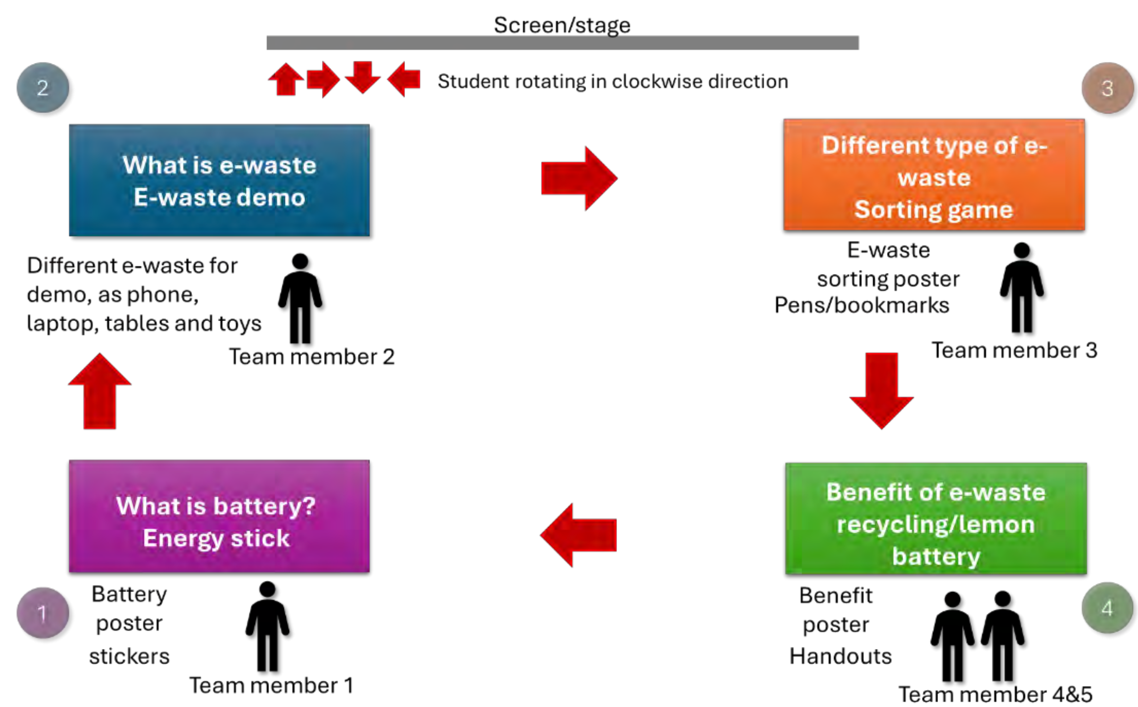


Figure 2. Mini-fair setup (4 stations).

1.2.4 Activity Table: Community Events, State Fairs, and STEM Events

Audience: Up to 400 people
Setting: Booth or designated event space
Duration: Full-day or drop-in format

Key Considerations:

- ☑ Offer a mix of activities for all ages (e.g., bingo, fishing game, posters)
- ☑ Prepare take-home materials (e.g., flyers, postcards, QR codes)
- ☑ Include educational content for adults (e.g., data security, recycling benefits)
- ☑ Use swag (e.g., stickers, stress balls) to attract booth traffic
- ☑ Ensure signage is clear and engaging
- ☑ Plan for booth staffing and restocking throughout the day

1.3 Example Outreach Supplies Checklist

Table 4 provides a sample checklist for outreach materials needed for e-waste outreach in schools.

Table 4. Example of checklist for outreach supply.

Items	Quanity	Check	Note
1. Laptop and cable for presentations			
• Laptop	1	☐	
• Laptop charge cable	1	☐	
• HDMI cable	1	☐	
2. Presentation file (downloaded)	1	☐	
3. Posters		☐	
• What is battery?	1	☐	
• Benefit of recycling e-waste	1	☐	
• What is e-waste?	1	☐	
4. Easels	6	☐	
5. Take-home Handouts	100	☐	
6. Flyers	10	☐	
7. E-waste demo devices	10	☐	Pre-disassembled e-waste (cell phone, computer, tablet) sample for demo
8. Energy sticks	10	☐	
• Insulators and conductors	2	☐	e.g., plastic, metals, paper
9. E-waste sorting cards	1	☐	Refer to Section 3 for Materials
10. E-waste tic-tac-toe game	1	☐	Digital game/question in middle school presentation
11. DIY lemon battery activity			
• Lemon	20	☐	Depending on number of students
• Mini lightbulbs	10	☐	Depending on number of students
• Conductors	20	☐	
• Plates	25	☐	
• Disposable plastic knives	10	☐	
• Copper tape	1	☐	
• Nail	20	☐	
12. Swag			
• Stickers	300	☐	Depending on number of students
• Highlighters	100	☐	Depending on number of students
• Stress Relievers	50	☐	Depending on number of students
13. Paper towel	2	☐	
14. Disinfection wipes	2	☐	
15. Hand sanitizer	4	☐	
16. Table clothes	3	☐	
17. Plastic disposable table covers	2	☐	
18. Scissors	1	☐	

SECTION 2. CURRICULUM AND PRESENTATION OVERVIEW

CURRICULUM AND PRESENTATION OVERVIEW

This section introduces an interactive and age-appropriate curriculum focused on e-waste recycling, specifically designed for elementary, middle, and high school students. The topics covered here introduce the foundational knowledge that applies across all grade levels. Educators can refer to this section for shared definitions, key concepts, and vocabulary used throughout the curriculum.

Learning Objectives: By the end of the curriculum, students will be able to do the following:

- Define electronics and identify common electronic items that become waste
- Understand the main components of batteries and how they work
- Know what to do with electronics at end-of-life
- Describe the advantages of properly recycling electronics
- Understand their role in responsible recycling behavior
- *(Middle/High School)* Define critical materials and explain their importance
- *(Middle/High School)* Identify critical materials found in electronics

2.1 *Curriculum Core Concepts*

This section outlines the essential ideas that form the backbone of the e-waste curriculum across all grade levels.

2.1.1 Electronics (Elementary/Middle)

Core Concept: Electronics are devices that need electricity to work and perform a specific task.

Starting with the basics, explain that when you turn on a flashlight, play a video game, or watch a cartoon, you are using electronics. These devices have tiny parts inside that help electricity move—like roads guiding cars. Some electronics plug into the wall, like TVs and ovens. Others use batteries, like remote controls and toys. Electronics are everywhere and help make life easier and more fun!

Key Vocabulary: Electronic, Electricity

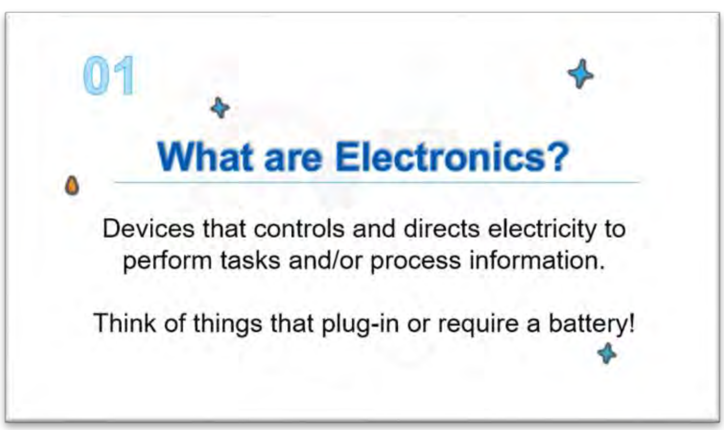


Figure 3. Sample presentation slide for defining electronics

2.1.2 Battery Basics (Elementary/Middle)

Core Concept: Batteries store chemical energy and release it as electricity when needed.

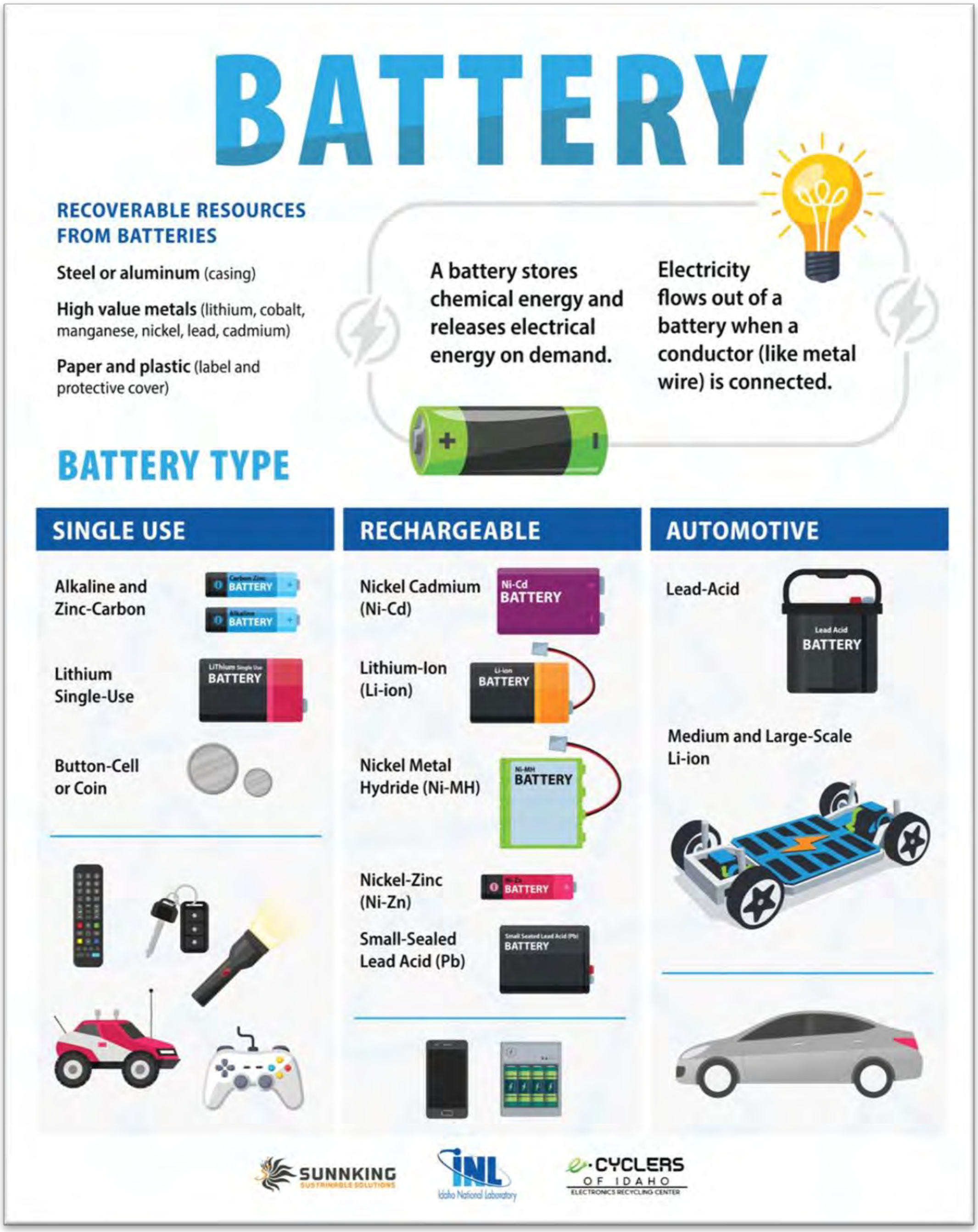


Figure 4. Example classroom or mini-fair informational poster for battery types.

It is important that students understand the basics of how batteries work, including the chemical reactions that power them and how they are used in everyday electronics.

Inside of a battery are two different metals (**electrodes**) and a special liquid or paste (**electrolyte**). These parts work together to create a chemical reaction that produces electricity. Once the battery is connected in a closed circuit, electricity flows and a device turns on.

Conductors and **insulators** play a key role in the flow of electricity through an electronic device. **Conductors** allow electricity to flow through wires and components, while **insulators** prevent unwanted flow and keep the energy safely contained within the circuit.

Batteries come in many types:

- Single use (e.g., AA, AAA)
- Rechargeable (e.g., lithium-ion)
- Automotive (used in vehicles and boats)

Key Vocabulary: Electrode, Electrolyte, Conductor, Insulator

2.1.3 Understanding E-waste (All Grade Levels)

Core Concept: E-waste is any electronic device that is no longer used or functional.

When a device stops working, we might fix it, replace the battery, or donate it. But if it cannot be repaired or its part cannot be used for other devices, it becomes e-waste. This includes old phones, broken computers, and used batteries. E-waste should never go in the regular trash because it contains materials that can harm the environment. Instead, we should recycle it properly.

- **E-waste is one of the fastest growing types of trash in the world because people keep buying new gadgets.**
- **Did you know? One AA battery thrown in the trash can pollute enough water to fill a swimming pool!**

Key Vocabulary: E-waste, Recycle, Repair, Reuse, Refurbish, Landfill, Resources, Safety

Figure 5. Example e-waste informational poster.

2.1.4 Benefits of Recycling E-waste (All Grade Levels)

Core Concept: Recycling e-waste protects the planet and saves valuable resources.

When we recycle electronics, we keep harmful materials out of landfills and recover useful parts like metals and plastics. This saves energy, reduces pollution, and helps protect animals, plants, and people. Recycling also means we do not have to mine as many new materials from the Earth.

- **Recycling e-waste = helping the Earth!**

Figure 6. Example recycling e-waste informational poster.

2.1.5 Critical Materials and Product Life Cycle (Middle/High School)

Core Concept: Electronics rely on essential materials that must be used wisely and recycled.

Every electronic device has a life cycle (Figure 7): it is made, used, and eventually discarded or recycled. These devices contain **critical materials** like lithium, cobalt, and rare earth elements, (Figure 8) which are essential for batteries, screens, and motors. These materials are limited and often hard to get, so recycling helps conserve them and reduces environmental harm.

Key Vocabulary: Critical Materials, Product Life Cycle

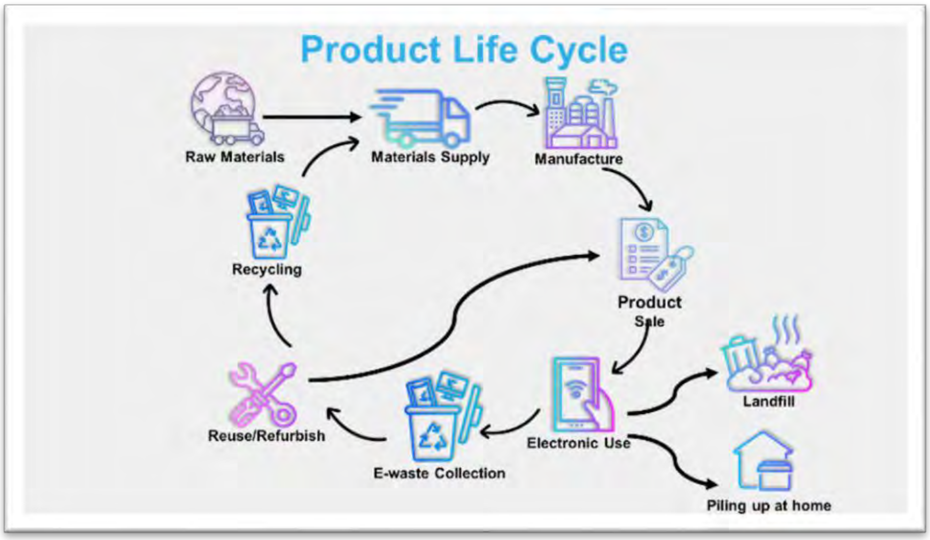


Figure 7. Example product life cycle slide for classroom presentation.

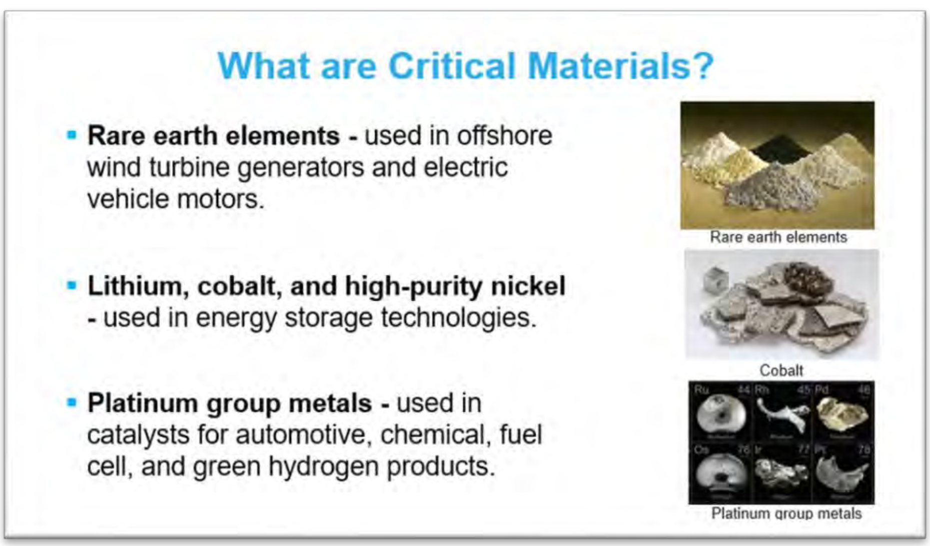


Figure 8. Example critical materials slide for classroom presentation.

GRADE-LEVEL CURRICULUM OUTLINES

2.2 Elementary School Curriculum Presentation Outline and Core Concept Expansions

This 30-minute interactive session is designed for both classroom and assembly settings. It introduces students to electronics, batteries, and e-waste through hands-on activities and age-appropriate discussions. Below are the topics, pacing, reference sections, important guiding questions and activity references. Use Table 5 to find the curriculum material most appropriate for the elementary grade level found in the 2.0 Core Curriculum section above.

Table 5. Elementary school presentation agenda.

Topic	Duration	Concept Reference Section	Guiding Questions	Activities/Demos
Intro	2 min	—	Team introduction and agenda overview	—
Electronics	8 min	2.1.1	• What are electronics? • What are some examples of electronics you might find at home (e.g., living room, kitchen)?	Electronics Demonstration (Section 3.1)
Battery Basics	5 min	2.1.2	• What is a battery? • How does a battery work? • What are the main components of a battery? • What are some categories of batteries? • What materials conduct or insulate electricity?	Energy stick (Section 3.2) /DIY lemon battery (Section 3.4)
Understanding E-Waste	3 min	2.1.3	• What happens to unused or broken electronics? • What are the categories of e-waste?	E-waste sorting game (Section 3.3)
Benefits of Recycling E-Waste	7 min	2.1.4	• Why recycle e-waste? • How does recycling e-waste help our community and environment?	Video: E-waste recycling process in industry- https://youtu.be/k7bHflfCtXw?si=A94mFAuhBfXJgjQG
Q&A	5 min	—	Questions and Answers	—

2.3 Middle School Curriculum and Presentation Outline and Core Concept Expansions

This 45-minute session builds on foundational concepts introduced at the elementary level and expands into more advanced topics such as critical materials and the **product life cycle** of electronics. Through hands-on demonstrations and interactive games, students deepen their understanding of how electronic devices work and what happens to them after use.

The Core Concept Expansion sections following Table 6 offer additional depth, connecting back to the 2.1 Core Curriculum and introducing additional related topics. Students explore the inner workings of electronics, learn what batteries are made of, and discover why materials like lithium and cobalt are essential (and limited) resources. They also examine how recycling helps reduce the need for mining, conserves natural resources, and protects the environment.

Table 6. Middle school presentation agenda.

Topic	Time	Concept Section	Guiding Questions	Activities/ Demos
Intro	2 min	—	Team introduction and agenda overview	—
Electronics and Battery Basics	8 min	2.1.1 2.1.2 2.3.1	• What is an electronic? What are some examples? • How does a battery work? • What are the main components of a battery? • What types of batteries are there? • What are they made of?	Electronics Demonstration (Section 3.1)
Understanding E-waste	15 min	2.1.3 2.3.2	• Why is e-waste a problem? • What is a product life cycle? • How does your family get rid of old electronics?	E-waste recycling process in industry (Video: https://youtu.be/k7bHflfCtXw?si=A94mFAuhBfXJqjQG)
Critical Materials and Product Life Cycle	10 min	2.3.3	• Why are some materials considered "critical"? • What are three common critical materials used in electronic devices?	-Critical Minerals demo -The Strength of Magnets Activity (Section 3.7)

Topic	Time	Concept Section	Guiding Questions	Activities/ Demos
Benefits of Recycling E-Waste	5 min	2.1.4	• What valuable materials can we recover from recycling e-waste? • How does e-waste recycling help protect the environment? • What harmful substances can be found in e-waste, and why should we keep them out of landfills? • How does recycling e-waste help save energy and natural resources?	E-Waste Tic-Tac-Toe (Section 3.5)
Q&A	5 min	—	Questions and Answers	—

2.3.1 Core Concept Expansion: Batteries

After discussing what electronics are and common household examples (Section 2.1.1), students explore how batteries work (Section 2.1.2) through learning additional terminology to gain a deeper understanding of these concepts.

Parts of a Battery

A battery has three main parts:

1. **Anode** (negative end): Where electrons are released.
2. **Cathode** (positive end): Where electrons are accepted.
3. **Electrolyte**: A chemical substance (liquid, gel, or paste) that allows ions to move between the **anode** and **cathode**.

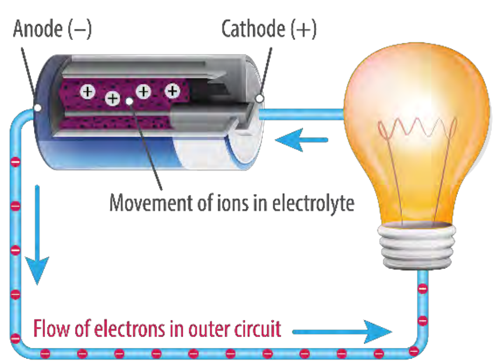


Figure 9. Battery circuit and component diagram.

How Batteries Work

When a battery is connected to a device (like a lightbulb or remote control—see Figure 9), a chemical reaction starts inside the battery:

1. The **anode** releases electrons.
2. These electrons travel through the **external circuit** (wires or metal parts) to reach the **cathode**.
3. As electrons move, they power the device—lighting it up, making it beep, or turning it on. This flow of electrons is called an **electric current**, and it is what makes your device work!
4. Inside the battery, **ions** move through the electrolyte to balance the charge.

Additionally, students learn about the main categories of batteries based on their uses and chemical make-up.

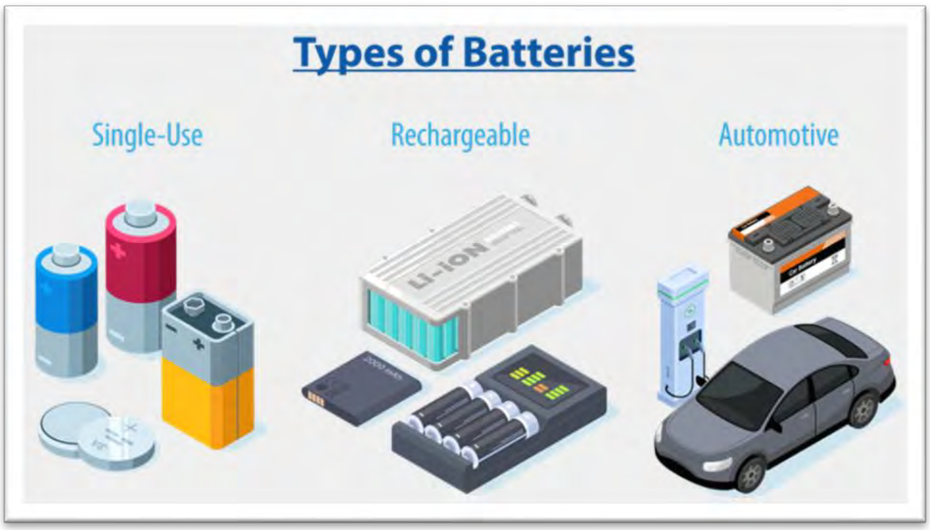


Figure 10. Battery type categories.

Types of Batteries

- Batteries come in various shapes and sizes (see Figure 10), such as **single-use types** (e.g., AA, AAA, C) and **rechargeable** (e.g., lithium-ion). Typically, batteries are named based on the materials used in their electrolytes or electrodes. For example, if lithium is used, the battery is called a lithium-ion battery.
- Another type is the **automotive battery**, which has a large capacity and can produce more electrical energy. This battery type is commonly used in vehicles.

2.3.2 Core Concept Expansion: Understanding E-waste

After exploring how rapid technological growth contributes to the rise of electronic waste (see Section 2.1.3), students will dive deeper into the different categories of e-waste (see Figure 11) and how they are classified. This section also introduces powerful statistics that illustrate the global scale of the e-waste crisis, helping students understand just how big the problem is and why their actions matter.

Figure 11. E-waste category slide for classroom presentation.

2.3.3 Core Concept: Critical Materials and Product Life Cycle

This section helps students understand the global importance of critical materials and how recycling supports their reuse.

Why Critical Materials Matter

Critical materials (e.g., lithium, cobalt, and rare earth elements) are essential for making these:

- Smartphones and tablets
- Electric vehicle batteries
- Wind turbines
- Medical devices and military equipment.

These materials are limited, have no easy substitutions, and are at risk in the global supply chain.

Why It Matters: The Scale of the Problem

- The world generated 62 million metric tons of e-waste in 2022. That's more than the weight of 6,000 Eiffel Towers!
- In 2022, only 22% of that e-waste was properly recycled.
- The remaining 78% were dumped, burned, or stored in homes. This wasted valuable materials and polluting the environment.
- E-waste is growing at a rate of 2.6 million tons per year, driven by short product lifespans and rapid tech upgrades.

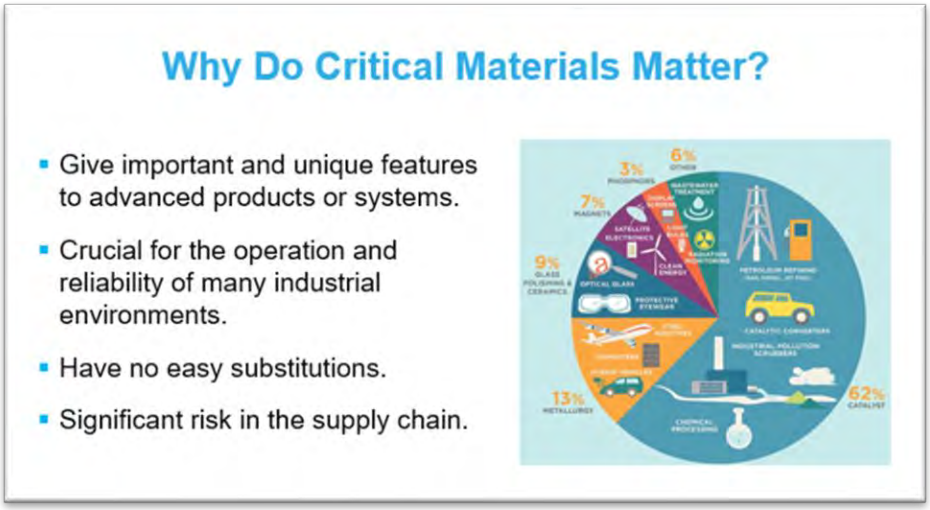


Figure 12. Importance of critical materials slide for classroom presentation.

2.3.4 Core Concept Expansion: Benefits of Recycling E-waste

Building on Section 2.1.4, students move beyond the basics of recycling to explore how e-waste recycling supports the global supply of critical materials and reduces environmental harm. This process protects people and the environment by keeping toxic materials out of landfills, creates jobs in recycling, refurbishing, and materials recovery industries, and helps reduce pollution while conserving energy.

Recycling end-of-life electronics allows us to do the following:

- Recover valuable materials and reintroduce them into the product life cycle
- Reduce the need for new mining**,** which can damage ecosystems and communities
- Conserve natural resources that are difficult or costly to extract
- Lower dependence on foreign sources for essential minerals.

Students explore how the recycling process works through an E-waste Recycling Process video (See Figure 12). Video - https://youtu.be/k7bHflfCtXw?si=A94mFAuhBfXJqjQG):

- Collection and Sorting – Devices are gathered and categorized
- Refurbishing and Reuse – Working parts are repaired and resold
- Shredding and Recovery – Non-reusable items are broken down to extract metals and minerals
- Reintegration – Recovered materials are used to manufacture new electronic.

2.4 *High School Curriculum and Presentation Outline and Core Concept Expansions*

2.4.1 Outline and Core Concept Expansions

This 50-minute interactive presentation starts with questions to gauge the students' knowledge. This curriculum agenda includes defining e-waste, a discussion on laptop disassembly and battery lifespan, explanation of product life cycle and critical materials, and the benefits of e-waste recycling. The duration of each section and the designed activities are detailed in Table 7.

Table 7. High school presentation agenda.

Topic	Time	Concept Section	Guiding Questions	Activities/Demos
Intro	2 min	—	Team introduction and agenda overview	—
Understanding E-waste	8 min	2.1.3 2.2.2	• What does your family do with old electronics that are no longer useful or functional? • What are the categories of e-waste? • How does the U.S. compare to other countries when it comes to recycling our e-waste? Why do you think that is the case?	E-waste recycling process in industry (Video: https://youtu.be/k7bHflfCtXw?si=A94mFAuhBfXJqjQG)
Product Life Cycle and Critical Materials	10 min	2.3.3	• Can you explain the electronics life cycle? Is there any part of this cycle that could affect you? • Can you give two reasons why we think some metals or materials are critical? • Can you suggest at least two ideas to help the U.S. boost e-waste recycling?	Optional Critical Mineral Toolkit Activity (Section 3.7)
Laptop Disassembly and Battery Lifespan	10 min	2.3.2	• What do you notice when you look inside the laptop cover? • What are the main components? • What materials do you think they are made of?	Laptop disassembly activity (Section 3.6)
Benefits of Recycling E-Waste	5 min	2.3.4	• What happens if we run out of materials to make new electronics, could you provide some ideas to prevent it? • What critical materials can we get back when we recycle old electronics? • How does recycling e-waste help keep our planet clean and safe? • What dangerous constituent is inside electronics, and why is it bad to throw them in the trash?	—
Review and Q&A	15 min	—	Refer to Trivia Question	Trivia/Kahoot (Section 3.8)

2.4.2 Core Concept: Understanding E-waste

See Section 2.1.3 and Section 2.3.2.

> **Core Concept**: Recycling e-waste not only protects the environment and conserves resources, but it also plays a vital role in global economics and national security by reducing our reliance on foreign sources for critical materials (see Sections 2.0.5 and 2.2.3 for core concept).

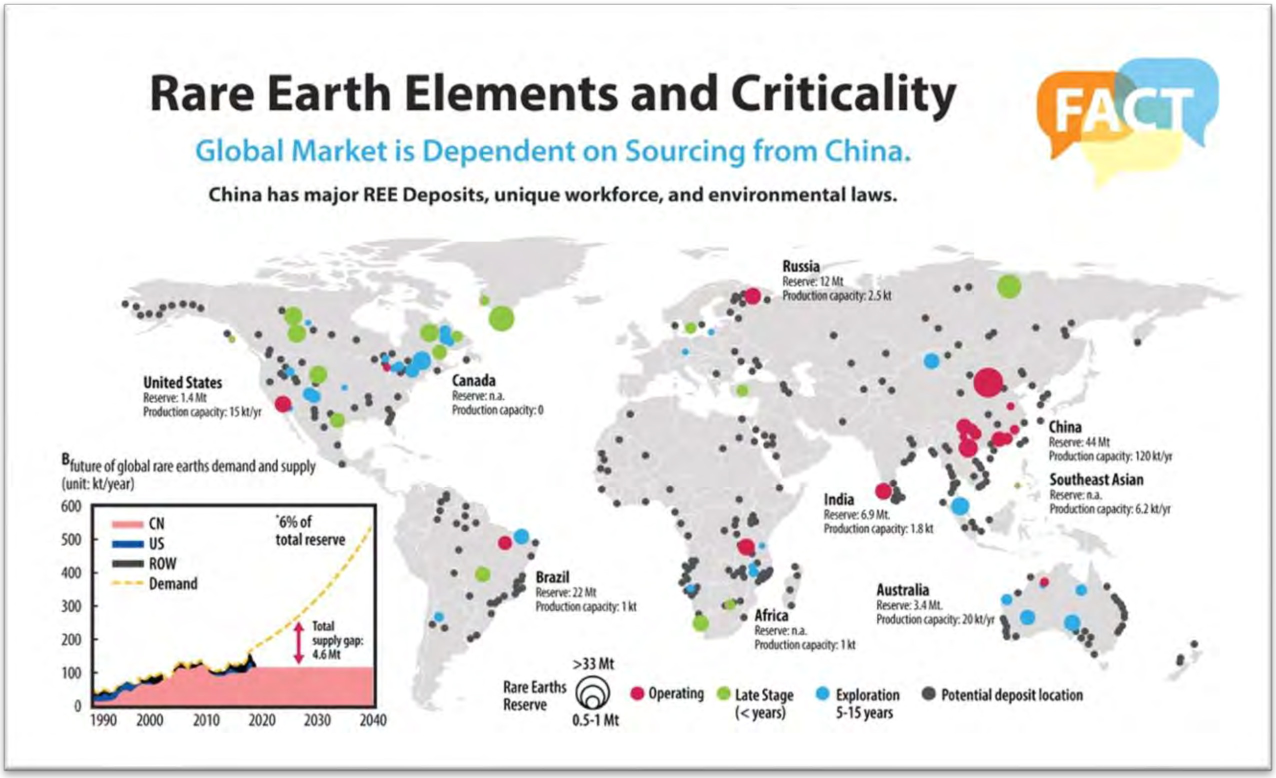


Figure 13. Rare Earth Elements and Criticality classroom presentation slide.[1]

2.4.2 Core Concept: Product Life Cycle and Critical Materials

Global Supply Chain Challenges (Figure 13)

- Many critical materials are mined in a small number of countries, often under unstable political or environmental conditions.
- For example, over 70% of cobalt comes from the Democratic Republic of Congo, and over 90% of rare earth elements come from China.
- This creates supply chain vulnerabilities and increases the risk of shortages, price spikes, and geopolitical tension.

1 Chen et. Al. 2024. "Interdependence in rare earth element supply and the United States helps stabilize global supply chains." Data sourced from USGS.

2.4.3 Laptop Disassembly and Battery Lifespan (High School)

See Section 3.6 for activity instructions.

In this section, students participate in a hands-on laptop disassembly activity, guided by instructors. This activity allows them to carefully open a laptop; identify key components, such as the motherboard, hard drive, and battery; and recognize the recycling potential of each part. This practical demonstration reinforces the concept of the product life cycle, illustrating how products are designed, used, and ultimately disposed of.

Key Vocabulary: Critical Materials, Battery

2.4.4 Core Concept: Benefits of Recycling E-waste

See Section 2.1.4 for the core concept and Section 2.3.4 for the extension information.

2.3.5 E-waste Trivia/Kahoot

See Section 3.8 for activity instructions.

SECTION 3. 10 E-WASTE HANDS-ON ACTIVITY LESSON PLANS

E-WASTE HANDS-ON ACTIVITY LESSON PLANS

This section outlines 10 hands-on activities/demonstrations designed to reinforce e-waste recycling concepts at different grade levels and settings (see Table 8). These can be used in the assembly/classroom presentations, at an e-waste mini fair, or at activity tables during school or community events. These interactive demonstrations help students connect abstract issues to real-world actions and enhance learning, encourage retention, and empower students to adopt sustainable habits early on.

Table 8. Hands-on activity and demonstration overview by appropriate grade level and setting.

Activity/Demo	Elementary	Middle	High	Setting
Electronic (E-waste) Demonstration (Section 3.1)	x	x	x	Assembly, Classroom, Mini-Fair, Activity Table
Energy Sticks (Section 3.2)	x	x		Assembly, Classroom, Mini-Fair, Activity Table
E-waste Sorting Game (Section 3.3)	x			Assembly, Classroom, Mini-Fair, Activity Table
Generate Electricity with a Lemon Battery (Section 3.4)	x	x		Mini-Fair, Activity Table
E-waste Tic-Tac-Toe (Section 3.5)		x		Classroom
Laptop Disassembly (Section 3.6)			x	Classroom
E-waste Critical Materials Activity (Section 3.7)		x	x	Classroom, Mini-Fair, Activity Table
E-waste Kahoot/Trivia (Section 3.8)			x	Classroom
Critical Material Fishing Game (Section 3.9)	x			Mini-Fair, Activity Table
Electronic Bingo (Section 3.10)		x	x	Classroom, Activity Table

3.1 Electronic (E-Waste) Demonstration

Learning Objective: This interactive electronic waste demonstration aims to illustrate to students the components found within everyday electronic devices and to facilitate discussions regarding batteries and electronic waste.

Grade Level: All
Setting: Assembly, Classroom Presentation, E-waste Mini Fair, Activity Table
Group Size: Small to large (used in classroom, fair activity and assembly presentations)
Duration: 5–8 minutes
Materials Supply:

- 3–6 different types of e-waste such as laptop, phone, tables, table setup refer Figure 14 and Figure 15. (Ensure all devices are fully decommissioned and safe for demonstration.)
- Labels for main components (e.g., CPU, hard drive, battery).
- Cut-resistant gloves (optional but recommended).
- Table (if needed for displaying devices).

Instructions:

1. Prep devices: Ensure devices are nonfunctional and clear of data. Remove the back cover ahead of time. Label main components.
2. Set up:
   - For small groups: Place devices on a table for students to explore (Figure 16 and Figure 17). Have students explore the devices on the table. Exercising caution and the safety reminder below.
   - For large groups: Each instructor or instructor aid can carry a different type of e-waste and circulate among the students, refer to Figure 18.
3. Safety reminder:
   - Devices are for demonstrations only—not for disassembly by students.
   - Warn about sharp edges; students must wear gloves if they are allowed to handle parts.

Questions to Ask Students:

- What do you observe inside this electronic waste?
- Are you able to identify each component within the laptops?
- What types of materials are used to manufacture these components?

Figure 14. Different types of e-waste demonstration.

Figure 15. E-waste demonstration setup.

Figure 16. Students obverse e-waste components.

Figure 17. E-waste demo in small-scale presentation.

Figure 18. E-waste demo in large-scale presentation.

3.2 Energy Sticks Activity

Learning Objective: The Energy Stick activity is used to explore how electrical energy flows through a closed circuit, reinforcing the concept that a complete path is required for a current to travel. Through hands-on experimentation, they will identify materials as conductors or insulators based on their ability to complete the circuit. The activity also introduces the role of the human body in conductivity and models how a battery functions as a power source by providing the energy needed to push electrons through the circuit. By comparing the Energy Stick's internal power source to a battery, students will gain a foundational understanding of how batteries enable current flow in everyday electrical systems. As students engage in energy sticks, refer to Figure 19.

Grade Level: Elementary/Middle School
Setting: Assembly, Classroom Presentation, E-waste Mini Fair, Table Activity
Group Size: 1–12 people at a time
Duration: 8–10 minutes

Materials Supply:

- Energy sticks
- Various objects (e.g., metal spoon, wooden spatula, plastic spoon, copper tubing, aluminum can)

Instructions for a single student (or the instructor):

1. Have the student hold one end of the Energy Stick with only one hand (nothing will happen).
2. Ask the student to touch both silver ends of the Energy Stick at the same time.
3. The Energy Stick will light up and buzz, showing that the circuit is complete.

Instructions for a large group:

1. Have a small group of students (3–10) form a circle and hold hands or touch fingers.
2. Ask two students next to each other in the circle to separate hands and have each hold different silver ends of the Energy Stick.
3. The Energy Stick will activate (light and buzz) when the circuit is complete.
4. Ask one pair of students to break the connection (i.e., let go of each other's hand).
   - The Energy Stick will stop, demonstrating an open circuit.
5. Try reversing the Energy Stick to see if it still works (it should because it is not polarity-sensitive).
6. Let one student hold different materials (e.g., glass, copper, aluminum) between connections to test conductivity:
   - Conductors (e.g., a copper tube or soda can) will complete the circuit.
   - Insulators (e.g., glass, wood, or plastic) will not.

Science Behind It:

The Energy Stick works by completing a simple electrical circuit using the human body. When a person touches both silver ends, their body (made mostly of water and minerals) acts as a weak conductor, allowing a small current to flow. This current activates the lights and buzzer, showing the circuit is complete.

Electricity is the flow of electrons (called current). Materials that allow this flow are called conductors (like copper, aluminum, and even the human body), while those that block it are insulators (like glass, rubber, and plastic). If the circuit is broken by letting go or using an insulation material, the current stops and the Energy Stick turns off. This demonstrates how circuits work and introduces the concept of conductivity in a safe, hands-on way.

Questions to Ask Students:

- Why does the Energy Stick buzz with some objects and not others?
- Can you think of real-life examples of conductors and insulators?

Reference:

- https://visithandson.org/wp-content/uploads/2021/03/Energy-Stick-instructions.pdf
- https://stevespangler.com/experiments/human-circuit/.

Figure 19. Students engaging in the Energy Stick activity.

3.3 E-waste Sorting Game

Learning Objective: The aim of this game is to educate students on the correct classification of waste materials, thus improving their comprehension of local recycling rules and encouraging responsible waste management behaviors. By engaging in the game, participants develop the skill to differentiate between items meant for landfill, compost, or various recycling categories (including e-waste, paper, plastic, and glass), which ultimately leads to more accurate sorting in real-world situations and a reduced environmental impact. To enhance the enjoyment of the game, students will be split into two teams and will compete against each other in terms of speed and accuracy in sorting waste.

Grade Level: Elementary/Middle School
Setting: Assembly, Classroom Presentation, E-waste Mini Fair, Activity Table
Group Size: 1–12 people at a time (minimum can host 1 student, maximum to 12 students)
Duration: 5–8 minutes

Materials Supply:

- For large group presentation: 3 large posters labeled Trash, Mixed Recycling, and E-Waste (33 in. × 46 in.; and Figure 20).
- For classroom activity: 3 small containers (same labels as above; Figure 22).
- 30–40 e-waste item cards (4 in. × 5 in.) with images or names of common items (Figure 23)
- Timer
- Prizes (optional)

Preparation Steps:

- Depending on the number of students in the group, the activity can be adjusted.
  - For a classroom setting, arrange three small containers on a table; see Figure 22.
  - For large presentation, utilize large posters like trash bins for the activity, as illustrated in Figure 21.
- For assembly and classroom presentation setting, the school or teacher can select 12 student volunteers, split into two teams of 6.
- Prepare two sets of 12 unique waste cards—no duplicates between teams—see Figure 23. Each student gets 2 cards.
- Assign a timekeeper.

Instructions:

1. Explain the rules: One person from each group picks up one card at a time, sorts it, and goes to the back of their team's line. The fastest and most accurate team wins!
2. Give examples of what belongs in each bin.
3. Stack each team's cards face down.
4. One at a time, hand a card to students and place it in the correct bin.
5. Time each team and check accuracy together after all cards are sorted.
6. The team with the most correct cards in the shortest time wins.
   - In case of a tie, the fastest individual sorter wins.
7. Distribute prizes to all participants; winners may receive extra or premium items.

Additional Notes:

- Discuss the importance of recycling and proper waste disposal
- Encourage the sharing of personal recycling practices and discuss safe disposal of old devices.

Figure 20. Example of trash bin-shaped cardboard.

Figure 21. Example for large-presentation setup.

Figure 22. Example for tabletop setup.

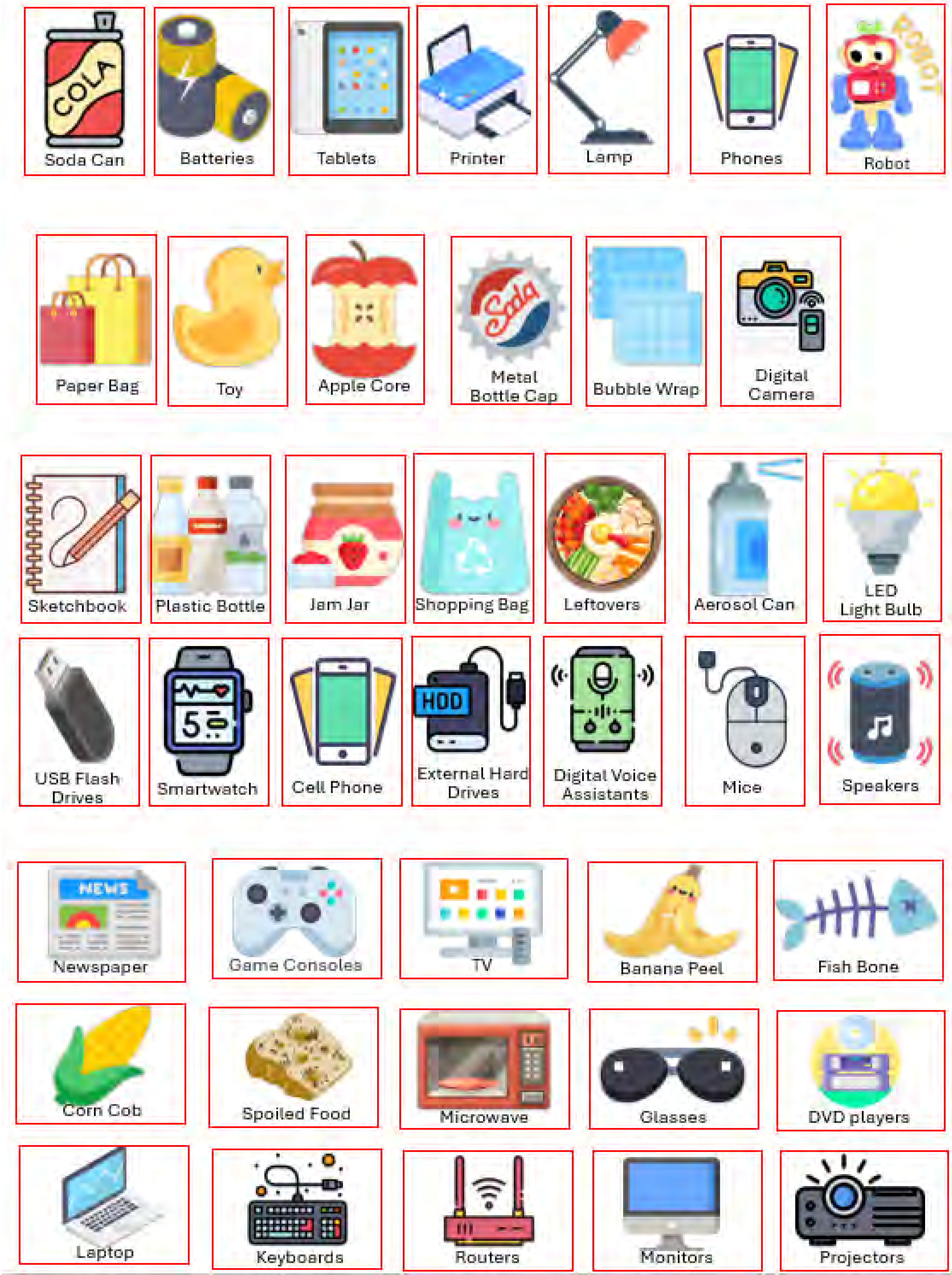


Figure 23. Example of e-waste item cards.

3.4 Generate Electricity with a Lemon Battery

Learning Objective: The DIY lemon battery activity supports the battery basics lesson or serves as an activity table at a community/school event or the e-waste mini-fair. It demonstrates how chemical energy is converted into electrical energy using a simple voltaic cell made from a lemon (citric acid as the electrolyte) and two different metals (zinc and copper as electrodes). This hands-on experiment introduces students to key concepts, such as galvanic corrosion, electrical circuits, and how batteries work, often powering a small LED light to show real-world application. (See Figure 24.)

Grade Level: Elementary/Middle School
Setting: E-Waste Mini Fair, Activity Table
Group Size: 2–6 students at a time
Duration: 5–10 minutes

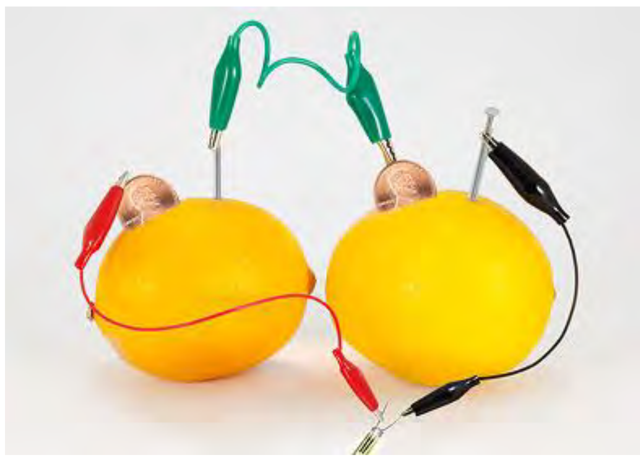


Figure 24. Example of lemon battery.

Materials Supply:

- Lemons – 1/student or 4+/students in series if powering a low-voltage LED
  - Note: one lemon = ~0.9 volts
- Zinc electrode (galvanized nail, zinc strip, or paper clip) – 1/lemon
- Copper electrode (pre-1982 penny, copper wire, or strip) – 1/lemon
- Alligator clip leads (found at most hardware stores) – 2/lemon
- Paper plates (1 per lemon)
- Plastic knife (for adult use only) – helpful for creating small slits in the lemons to accommodate the insertion of the metal electrodes
- Low-voltage LED, LCD clock, or calculator
- Voltmeter (optional)

Instructions:

Preparation for teachers/ instructors:

1. Roll each lemon gently on a table to loosen up the juice inside, making sure you do not break the skin. This helps the lemon juice act as a better electrolyte (see Figure 26).
2. Place a lemon on a plate and make two small parallel cuts, about 1–2 inches apart (see Figure 24).

Students:

1. Insert a penny (copper) into one cut until it sits halfway into the lemon.
   a. The copper coin or wire is your positive (+) terminal.
2. Insert the zinc nail into the other cut. Make sure that the nail and penny are not touching inside the lemon.
   b. The zinc nail is your negative (-) terminal.
3. To power a low-voltage LED bulb, place multiple (4+) lemons in series (see Figure 25 and Figure 27) by connecting the copper penny of one lemon to another lemon's zinc nail to make a loop (series) between all of the lemons.
4. Connect a test lead from the last zinc nail to the short leg of the LED (negative).
5. Connect a test lead from the first copper penny to the long leg of the LED (positive).
6. Test the lemon battery with a small LED light ball (see Figure 25).

Tip: If the light does not turn on right away, try reversing the clips on the light. Check that all your connection points are secure and ensure the copper and nail do not touch each other on the same lemon. You can also connect more lemons in a series to generate more power.

Additional Notes:

- Assign students roles if they are in groups and have them rotate roles so everyone has a chance to participate
- Discuss the results and explore different configurations
- Ensure safety by supervising the use of knives
- Discuss the science behind why the lemon battery works.

Questions to Ask Students:

- What are the components of a battery?
- Would different materials make different batteries?
  Explore how different metals and chemicals affect battery performance.
- What would happen if we used two pennies instead of a penny and a galvanized nail?
  This challenges students to think about why different metals are necessary for the chemical reaction to occur.
- Do you think other fruits or vegetables would work?
  This encourages further experimentation and helps students explore variables like the type of electrolyte.

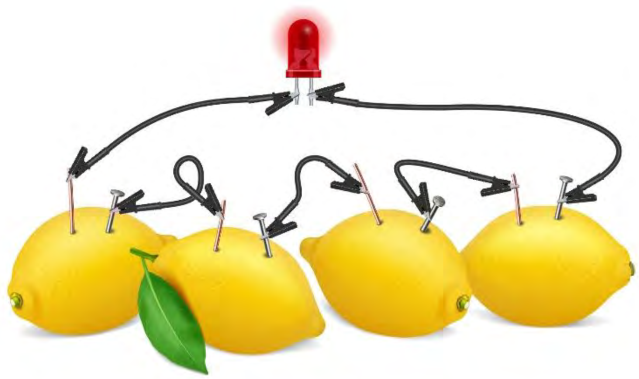


Figure 25. Example of lemon batteries connected in series with LED.

Figure 26. Example of preparing lemon for the activity

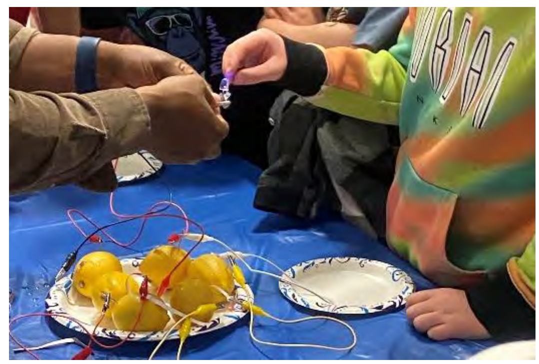


Figure 27. Example of testing lemon batteries with LED.

Reference:

- https://www.nationalelectronicsmuseum.org/wp-content/uploads/Flow-of-Electrons-Circuits-and-Batteries-Lesson-Plan.pdf.

3.5 E-waste Tic-Tac-Toe

Learning Objective: This e-waste tic-tac-toe game (Figure 28) reinforces content while offering choices for practice, assessment, and differentiated instruction. This approach utilizes a familiar game format to enhance critical thinking and problem-solving abilities, foster social interaction, and provide immediate feedback on learning.

Grade Level: Middle/High School
Setting: Classroom
Group Size: 2+ students (split into 2 teams)
Duration: 5–10 minutes

Instructions:

1. Divide the students into two teams, with each team selecting an icon, either “O” or “X,” and determining which team will go first.
2. The teams will alternate in choosing a number and answering the question behind each number.

3. If a team answers correctly, they will get an "O" or "X" on that square. Should a team fail to answer correctly three times, the question will be withdrawn, and the turn will pass to the other team. If another team gets the correct answer, they get the square.
4. The first team to achieve three Os or Xs in a row (vertically, horizontally, or diagonally) is the winner. If no one gets three in a row, the game will end once all nine squares are filled and will be considered a tie.

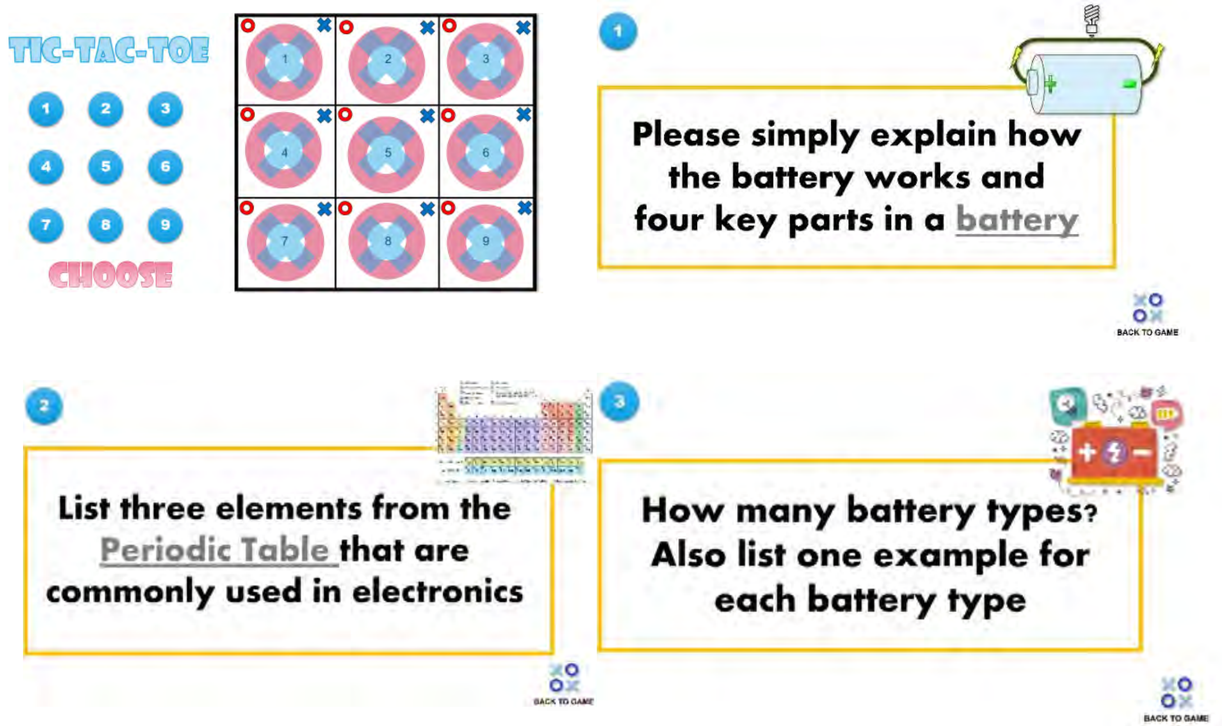


Figure 28. Example of e-waste tic-tac-toe.

3.6 Laptop Disassembly

Learning Objective: This hands-on activity reinforces concepts from the electronics and battery lecture by allowing students to disassemble a laptop and identify key components such as the motherboard, hard drive, and battery. It helps students understand how these parts function and introduces the recycling options associated with each.

In addition to deepening their understanding of technology, students gain practical skills like using tools, following instructions, and working with precision. The activity also encourages collaboration and connects theoretical knowledge to real-world applications.

Grade Level: High School
Setting: Classroom Presentation
Group Size: 2–30 students
Duration: 10–15 minutes

Materials Supply:

- Nonfunctional laptops (6–8)
- Basic toolkit (6–8): Screwdrivers, including small/specialized screwdrivers
- Labels for battery questions (Table A-1)
- Labels for main components (Table A-2)
- 6–8 plastic pry (to help open the case)
- Optional: 20 safety goggles
- Optional: Latex/nitrile gloves (20–25 pairs)
- 6–8 small containers or plastic bags to place screws or small components.

Preparation Setup:

Shut down the laptop completely, then press and hold the power button for 10 seconds to discharge residual power. Remove any external devices (e.g., USBs, SD cards). Unscrew the back of the laptop and label each part inside the laptop, such as RAM, cooling fan, CPU, and hard drive as well as main critical materials in that component (Figure 29).

Figure 29. Example of laptop disassembly.

Figure 30. Question behind laptop battery.

Figure 31. Students working on laptop disassembly.

Instructions:

1. Divide students into groups of 2–4 (Figure 31).
2. Review important safety practices.
3. Unscrew the bottom panel
   - Flip the laptop over.
   - Remove all visible screws from the bottom panel.
   - Some screws may be hidden under rubber feet or stickers—check carefully.

4. Pry Open the Case
   - Use a plastic pry tool to gently separate the bottom panel from the chassis.
   - Be patient, do not force it or use metal tools that could damage the case.
5. Instruct students to disassemble recycled laptops to take out the battery, keeping disassembled components organized in bins/boxes
   - Locate the battery connector and gently unplug it from the motherboard.
   - Remove any screws by holding the battery in place, then lift the battery out.
6. Identify the labeled critical material on each component.
7. Find the question under the battery then discuss with group members (Figure 30).
8. Secure the laptop's case by screwing it back on. If students are short on time to reattach the laptop case, simply place the screws and tools in a small container or plastic bag to make organization easier.

Additional Notes:

- Always ground yourself to avoid static shock.
- Never force a component, if it does not come out easily, double check for hidden screws or clips.
- Be especially careful with ribbon cables, they are fragile.
- Review all critical materials in laptop batteries once all the groups are done reassembling their laptops.
- Emphasize the importance of these skills in computer engineering and environmental careers.

Questions to Ask Students:

- What kind of battery is this? What critical materials are included in the battery? (Figure 30)
- What precautions should you take when handling a recycled laptop battery?

3.7 *Critical Materials Activity/E-waste Discussion*

Learning Objective: This activity uses the Critical Materials Institute (CMI) educational toolkit to guide students in exploring the product life cycle and the importance of critical materials through the lens of e-waste and electronics disassembly. Students will engage in discussions about which components can be recycled and why, reinforcing the value of responsible recycling. The activity may include small demonstrations—such as mining samples or rare earth magnet exercises—to support the conversation and transition into the "Benefits of E-waste Recycling" presentation

Grade Level: Middle/High School
Setting: Classroom Presentation (Optional Curriculum Extension), Mini Fair, Table Activity
Group Size: 2+
Duration: 5–8 minutes

Materials Supply:

- CMI educational toolkit (see Figure 32)
- Samples of critical materials
- Rare earth element magnets
- "The Strength of Magnets" exercise from CMI toolkit, refer to Figure 33
- Unlabeled laptop battery or electronic.

Instructions:

There are multiple educational activities in the CMI toolkit: https://www.youtube.com/watch?v=f-0NjHBl7sY. For the presentations for middle and high school, you can choose to incorporate the following options:

1. In the CMI toolkit, there are two mine samples (rock and sand) in small containers. Hand out mine samples for the class to pass around and examine.
2. Take out phone or hard drive sample and ask the class to identify each of the critical materials contained in those devices.

Questions to ask students:

- Where do you think other rare earth elements are found in everyday items?
- What is an example of e-waste in your house? What materials or elements are contained in that device?
- What happens to the electronics in your house after they stop working?
- What are some obstacles to recycling e-waste? What are some solutions?
- Discuss how recycled e-waste can undergo a process to recover rare earth elements for use in other electronics/technologies.

Additional Notes:

- If any student mentions recycling electronics, ask them to describe the process.
- Emphasize careers in e-waste recycling and the importance of critical materials.
- There are multiple educational activities in the CMI toolkit. To review and find more activities, follow the link: https://www.youtube.com/watch?v=f-0NjHBl7sY.

Reference:

- CMI lesson plans: https://www.ameslab.gov/cmi/cmi-lesson-plans
- Toolkit activity video: https://www.youtube.com/watch?v=VPIYnwr8tr4

Figure 32. CMI educational toolkit.

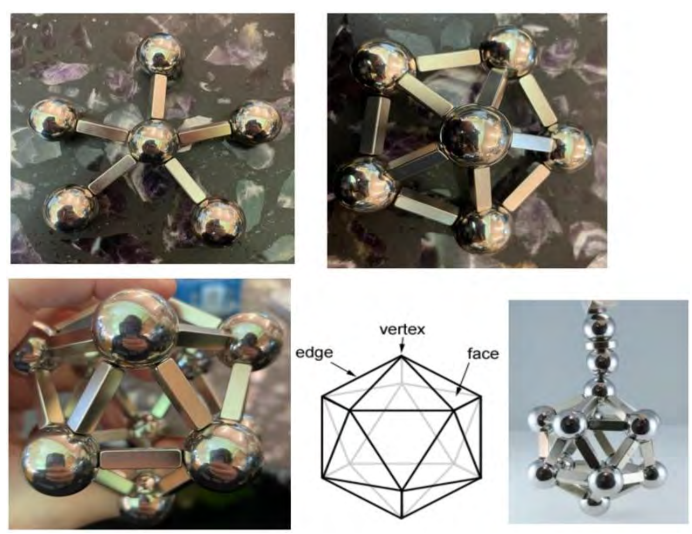


Figure 33. "The Strength of Magnets" exercise from CMI toolkit.

3.8 E-waste Kahoot/Trivia

Learning Objective: The E-waste Kahoot or E-waste Trivia serves as an educational activity aimed at enhancing engagement, motivation, and knowledge retention by converting lessons into interactive, game-based experiences for learners. These tools are adaptable resources utilized to evaluate prior knowledge, introduce new concepts, and reinforce learning through review. Additionally, they offer valuable feedback that enables us to customize instruction according to the needs of students.

Grade Level: High School
Setting: Classroom
Group Size: 4–10+ students (apply to classroom type of outreach)
Duration: 10–15 minutes
Materials:

- Kahoot quiz (Figure 34) covering all information from the lesson and supplemental reading materials for Kahoot (see "The Compositions of an iPhone in the appendix). (If you do not have a Kahoot account, the high school presentation slides have the same questions in a trivia format. Put students in groups and have them answer using A, B, C, D answer cards.)
  - Digital Quiz Link: https://create.kahoot.it/share/presentation-iphone-assembly/25f4afd6-a9bd-4b42-9074-a2bb7277124c
- Prizes for three top three scoring participants (optional).

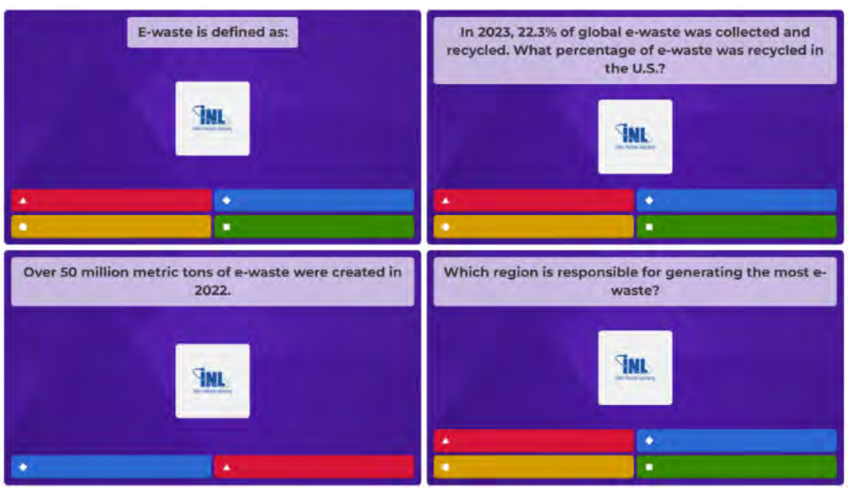


Figure 34. Example of e-waste Kahoot.

Instructions:

1. Play the Kahoot on a projector.
2. Ensure all students have joined the room, then begin the quiz.
3. Students compete to answer questions correctly and quickly.
4. At the end of the quiz, pass out prizes to the winners (optional).
5. Answer any questions that students may have, leading to a short discussion, if needed.
6. Emphasize the different career paths available in the various sectors covered during the presentation.

Additional Notes:

- Students will compete in a Kahoot that covers all the information from the lesson. There will be prizes for the top three scoring participants. If the class size is too large, students will work in pairs to complete the Kahoot.
- Use this activity to reinforce key concepts and encourage engagement.

3.9 *Critical Material Fishing Game*

Learning Objective: This activity introduces the topic of critical materials and explores the connection between electronics and critical materials in a hands-on and engaging way.

Grade Level: Elementary/Middle School
Setting: E-waste Mini Fair, Activity Table
Group Size: 1–2 people at a time
Duration: 3–5 minutes

Materials Supply:

- 2 toy fishing rods
- 10–12 fish icons with magnet, add one critical material label on the back of each fish (Figure 35).
- A stack of electronic item cards (Figure 23).
- Answer sheet (optional) to help navigate which electronic and critical materials match.
- Swag (optional) for children who participate.

Instructions:

1. Introduce the Activity – Briefly explain that many electronics rely on rare or critical materials, and this game helps identify which ones are found in common devices.
2. Participant Chooses a Device – Ask the participant to draw one electronic item card from the stack.
3. Fishing for Materials – Based on the selected device, instruct the participant to “fish” for at least two critical materials that are used in that item(Figure 36 through Figure 38).
4. Attempts and Feedback
   - Allow three fishing attempts (or more, depending on your group size and time).
   - After each attempt, let the participant know whether they have correctly identified a material used in the device.
   - If they succeed early, you can still let them try to find more materials for bonus learning.

Questions to Ask:

- Why are those materials considered critical?
- How are they sourced and why does recycling or conservation matters?
- What role do these materials play in the function of the selected device?

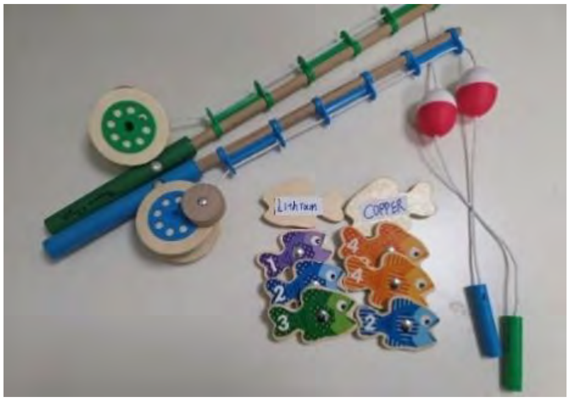


Figure 35. Example of toy fish and rod.

Figure 36. Example of demonstration fishing game.

Figure 37. Kids participated in fishing game.

Figure 38. Fishing game at the community fair.

3.10 Electronic Bingo

Learning Objective: This activity is designed to help participants distinguish between electronic devices that require data removal before recycling and those that do not. Through an engaging electronic bingo game, students and community members will learn that while devices like phones, laptops, and Wi-Fi routers store personal data and must be wiped before recycling, others devices like keyboards and ovens do not. The activity supports gaining an understanding of data security in e-waste recycling.

Grade Level: Age 10 and above
Setting: Activity Table Time
Group Size: 4–8 people at a time (Figure 40 and Figure 41)
Duration: 5–8 minutes

Materials Supply:

- 8–10 laminated bingo sheets (Figure 39)
- A stack of random electronic cards.

- 10–12 dry erase marker
- Paper towel or wiper to clean.

Instructions:

1. The game instructor will pick an electronic from a stack of cards.
2. Participants need to find the correct category on the bingo sheet then mark the square.
3. Players shout “BINGO!” when they get a full line (vertical, horizontal, or diagonal) or a full card.

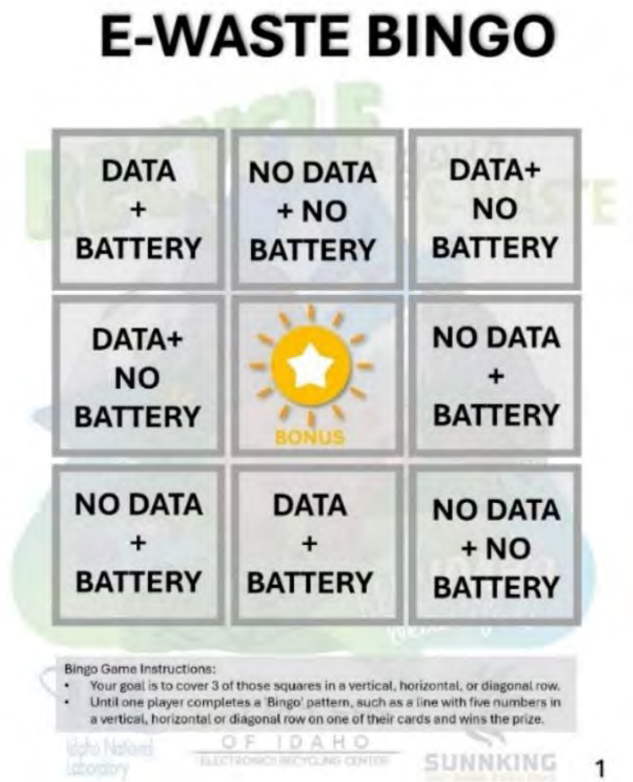


Figure 39. Example of bingo sheet.

Figure 40. Example of doing bingo.

Figure 41. Bingo game at community event.

SECTION 4. PLANNING E-WASTE COLLECTION AT SCHOOLS

PLANNING E-WASTE COLLECTION AT SCHOOLS

4.1 Planning a School-Based E-waste Recycling Program

A successful e-waste collection initiative begins with collaborative discussions between the recycling organization and the school to align shared goals. These typically include raising awareness about electronic waste, promoting environmental responsibility, diverting e-waste from landfills through safe and sustainable practices, and offering student incentives, such as refurbished electronics or recognition programs, to encourage active participation.

Following this alignment, the development and implementation of a successful e-waste recycling program in K–12 schools require careful planning. Key considerations include the availability and sourcing of recyclable materials, budgetary constraints, optimal timing for collection events, and logistical coordination for transportation and storage.

To ensure an efficient and impactful rollout, facilitators should follow a structured planning process (see Figure 42) that outlines the helpful steps for launching and sustaining a school-based e-waste collection initiative.

Step 1: Establish the Partnership

At the beginning of this process, it is important to formalize collaboration between the e-waste recycling company and the school.

From e-waste recycling company perspective: The e-waste recycling company begins by contacting the district superintendent to request approval for launching the program across the school district. Once approved, the company reaches out to individual school principals or administrators to coordinate participation at each school. After school-level approval is secured, planning for logistics (see Step 2) can begin. To encourage student involvement, the recycling company may offer incentives.

From a school perspective: Schools or teachers aiming to enhance students' understanding of e-waste recycling and foster a recycling habit can connect with local companies certified in global standards for e-waste recycling such as Responsible Recycling Version 3 (R2v3) and the Recycling Industry Operating Standard (RIOS). These certified companies ensure that personal data is securely erased before any refurbishment or recycling takes place, adhering to global standards for processing e-waste. Once a partnership is established, the next step is to coordinate the logistics for collection with the recycling company.

Involving the Parent-Teacher Association and student clubs is optional but highly beneficial. These groups can do the following:

- Promote events among families and peers
- Assist with organizing and supervising the collection
- Help answer questions and boost community engagement.

Step 2: Collection Logistics Planning

Both the recycler and school should agree on a timeframe that aligns with the school's calendar and capacity. Once a timeline is established, the recycling company should deliver and position a designated e-waste bin in a location that is convenient and manageable for the school staff and students.

Depending on the school's schedule, the recycling company can offer educational sessions on e-waste recycling, facilitate student-led activities, and help promote the collection event within the school. Additionally, distributing handouts to students allows students to take information home to share with their parents.

The school can add a reminder to the morning announcements for students to bring their e-waste for drop-off; furthermore, schools or teachers can send reminder emails to parents and share details on social media to increase awareness of this collection program.

NOTE: *The bin should be clearly labeled, and the recycling company should supply a list of acceptable items to ensure proper use and contact information for when the bin gets full.*

Typically, schools collect small e-waste items such as these:

- Mobile phones
- Laptops
- Used batteries
- Small battery-powered devices
- Optional Large-Item Collection—If requested by the school, a special collection drive can be arranged for larger items like:
  - Refrigerators
  - Televisions
  - Washing machines
  - Other large electronic appliances.

Continued communication between the e-waste recycling company and the school should be maintained throughout the collection period so that the schools are supported and bins remain manageable.

Step 3: Wrap-up and Celebrate

After the collection period ends, the recycling company will need to pick up the e-waste bins, weigh the collected items, and share the results with the school.

If agreed upon, the recycling company may also offer incentives to students or the school.

To celebrate the effort and share outcomes, the school and recycling company can host a recognition event or ceremony. During this event, the recycling company can do the following:

- Present the collection results
- Distribute feedback forms to teachers and administrators to gather suggestions for improving future programs and educational sessions.

For long-term impact, the recycling company can propose a sustainable plan to install a permanent e-waste collection bin on campus. This would allow parents and community members to safely drop off their e-waste year-round, extending the program's benefits beyond the school.

Figure 42. Suggested steps for planning a school e-waste recycling program.

4.2 Responsibility of Stakeholders

A successful school-based e-waste recycling program relies on clear roles and active collaboration between the recycling company and the school community. Each stakeholder plays a vital part in ensuring the program is educational, efficient, and impactful.

Responsibilities of the E-Waste Recycling Company

The recycling company brings technical expertise and logistical support to the program. Their responsibilities are as follows:

- Program Guidance and Compliance – Advise schools on which electronic items are acceptable for recycling (e.g., phones, laptops, batteries) and ensure all materials are collected, transported, and processed in accordance with environmental regulations.
- Collection Infrastructure – Provide clearly labeled collection bins, schedule timely pickups, and offer optional large-item collection drives when requested by the school.
- Educational Support – Deliver age-appropriate educational materials and presentations to help students understand the importance of e-waste recycling and its environmental impact.
- Incentives and Engagement – While optional, offering incentives, such as refurbished electronics, certificates, or school-wide recognition, can significantly boost student and family participation. These incentives can be tailored to meet the needs of each school and community, especially in areas where recycling habits are still developing.
- Program Improvement – Gather feedback from school staff and administrators to refine future collection events and educational outreach.

Responsibilities of the School and Community Partners

Schools play a central role in promoting and facilitating the program. Their responsibilities include these:

- **Administrative Coordination**
  Secure district and school-level approval, designate a staff liaison, and coordinate with the recycling company on scheduling and logistics.
- **Community Engagement**
  Involve the Parent-Teacher Association, student clubs, and classroom teachers to help promote the event, supervise collection activities, and encourage participation.
- **Communication and Promotion**
  Distribute educational materials and event announcements to students and families. Use school newsletters, websites, and social media to raise awareness.
- **Support and Feedback**
  Monitor the collection bin, report any issues, and participate in post-event evaluations to help improve future programs.

Together, these shared responsibilities ensure that the e-waste recycling initiative is not only operationally successful but also fosters long-term environmental awareness and sustainable habits among students, families, and the broader community.

4.3 Communication Materials

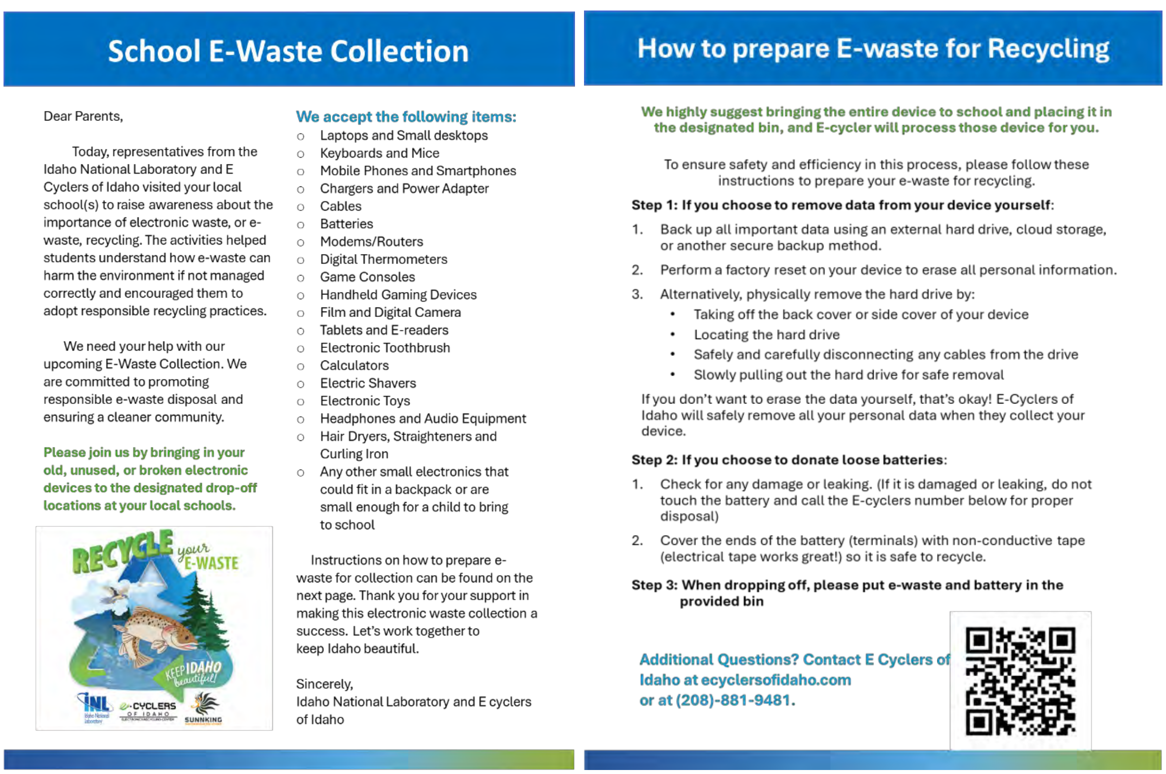
Effective communication is essential to the success of a school-based e-waste recycling program. Regular coordination meetings between the school and the recycling company help align logistics, safety protocols, and contingency plans. Post-event follow-up is equally important; sharing results (e.g., total weight of e-waste collected) and recognizing participants help reinforce the program's impact.

Educational and Promotional Materials:

Tailored communication materials help engage students and families across all grade levels:

- **Elementary and Middle School**:
  A letter to parents (see Figure 43) should be sent home to explain the event, list acceptable items, and provide instructions for preparing e-waste. To make the program more engaging for younger students, the following can be included:
  - Word search games (Figure A-4 and Figure A-5)
  - Crossword puzzles (Figure A-6 and Figure A-7)
  - Coloring sheets (Figure A-8 through Figure A-10).
- **High School**:
  A postcard (see Figure 44) can be distributed with key event details, a list of acceptable items, and information about the recycling company for students who want to learn more or get involved.

By combining clear communication with fun, age-appropriate materials, schools can foster excitement and participation while reinforcing environmental responsibility.



School E-Waste Collection

Dear Parents,

Today, representatives from the Idaho National Laboratory and E Cyclers of Idaho visited your local school(s) to raise awareness about the importance of electronic waste, or e-waste, recycling. The activities helped students understand how e-waste can harm the environment if not managed correctly and encouraged them to adopt responsible recycling practices.

We need your help with our upcoming E-Waste Collection. We are committed to promoting responsible e-waste disposal and ensuring a cleaner community.

Please join us by bringing in your old, unused, or broken electronic devices to the designated drop-off locations at your local schools.

We accept the following items:

- Laptops and Small desktops
- Keyboards and Mice
- Mobile Phones and Smartphones
- Chargers and Power Adapter
- Cables
- Batteries
- Modems/Routers
- Digital Thermometers
- Game Consoles
- Handheld Gaming Devices
- Film and Digital Camera
- Tablets and E-readers
- Electronic Toothbrush
- Calculators
- Electric Shavers
- Electronic Toys
- Headphones and Audio Equipment
- Hair Dryers, Straighteners and Curling Iron
- Any other small electronics that could fit in a backpack or are small enough for a child to bring to school

Instructions on how to prepare e-waste for collection can be found on the next page. Thank you for your support in making this electronic waste collection a success. Let's work together to keep Idaho beautiful.

Sincerely,
Idaho National Laboratory and E cyclers of Idaho

How to prepare E-waste for Recycling

We highly suggest bringing the entire device to school and placing it in the designated bin, and E-cycler will process those device for you.

To ensure safety and efficiency in this process, please follow these instructions to prepare your e-waste for recycling.

Step 1: If you choose to remove data from your device yourself:

1. Back up all important data using an external hard drive, cloud storage, or another secure backup method.
2. Perform a factory reset on your device to erase all personal information.
3. Alternatively, physically remove the hard drive by:
   - Taking off the back cover or side cover of your device
   - Locating the hard drive
   - Safely and carefully disconnecting any cables from the drive
   - Slowly pulling out the hard drive for safe removal

If you don't want to erase the data yourself, that's okay! E-Cyclers of Idaho will safely remove all your personal data when they collect your device.

Step 2: If you choose to donate loose batteries:

1. Check for any damage or leaking. (If it is damaged or leaking, do not touch the battery and call the E-cyclers number below for proper disposal)
2. Cover the ends of the battery (terminals) with non-conductive tape (electrical tape works great!) so it is safe to recycle.

Step 3: When dropping off, please put e-waste and battery in the provided bin

Additional Questions? Contact E Cyclers of Idaho at ecyclersofidaho.com or at (208)-881-9481.

Figure 43. Letter to parents.

Figure 44. Postcard for high school students.

APPENDIX
POSTERS, HANDOUTS, AND PLANNING RESOURCES

Figure A-1. Example of education poster, size (36 × 48 inches).

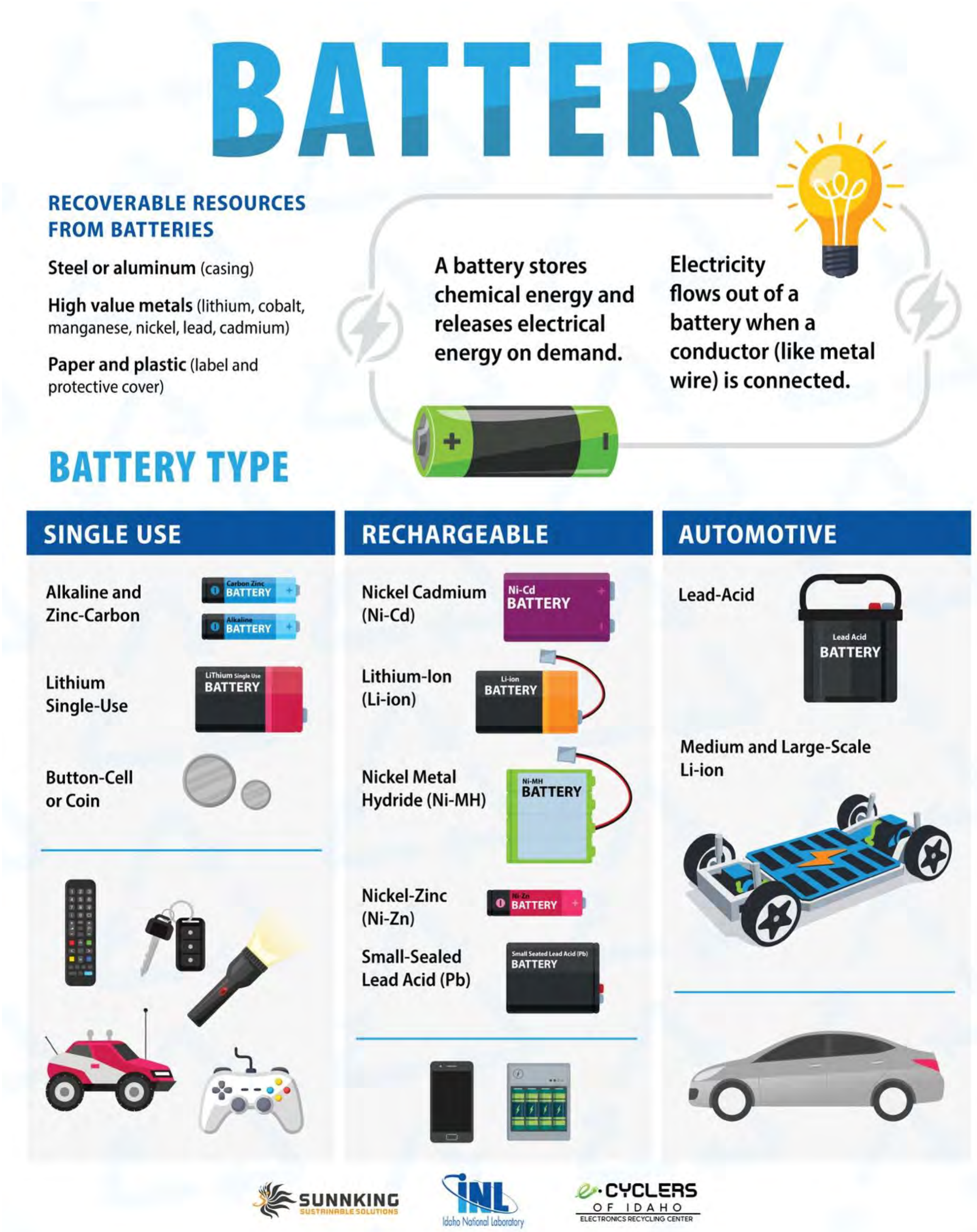


Figure A-2. Example of education poster (cont.), size (36 × 48 inches).

Figure A-3. Example of education poster (cont.), size (36 × 48 inches).

Figure A-4. Word search game.

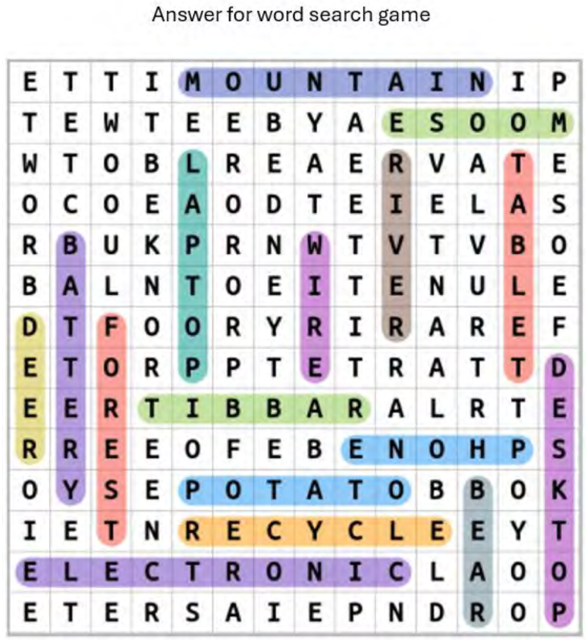


Figure A-5. Word search game answer sheet.

Figure A-6. Crossword game.

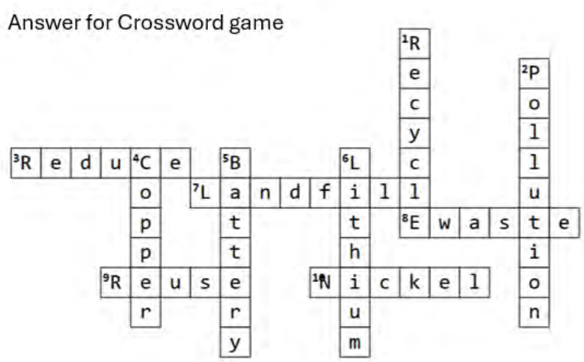


Figure A-7. Crossword game answer sheet.

Figure A-8. Example coloring sheet (bear).

Figure A-9. Example coloring sheet (moose).

Figure A-10. Example of coloring sheet (fish).

Table A-1. Printable laptop battery questions.

1. Can you guess what percentage of lithium is in a laptop battery?	**2. How can students help recycle more electronics in everyday life?**
3. How can we safely store and recycle lithium-ion batteries at home, school, and in our communities?	**4. Can you guess which kinds of electronics are being recycled the most?**
5. What are three common pathways for end-of-life electronics?	**6. What roles can state and local governments (such as cities and counties) play in recycling?**
7. What makes a critical material *critical*? Think of a few reasons why critical materials are so important to producing products in the United States.	**8. Which primary material do you think is most often recovered from E-waste recycling (metal, plastic, glass)?**

Table A-2. Printable laptop components label.

Battery: Powers the device. Often has lithium, cobalt, nickel, graphite.	**Battery:** Powers the device. Often has Lithium, Cobalt, Nickel, Graphite.
Hard Drive (HDD): Stores your data. Should be wiped/removed if laptop is recycled. Rare earth elements (neodymium, praseodymium) and precious metals like gold, silver, and platinum are in hard drives.	**Hard Drive (HDD):** Stores your data. Should be wiped/removed if laptop is recycled. Rare earth elements (neodymium, praseodymium) and precious metals like gold, silver, and platinum are in hard drives.
Fan: Cools the laptop down. Made of plastics and often aluminum.	**Fan:** Cools the laptop down. Made of plastics and often aluminum.
Circuit Board: Connects electronic parts of laptop.	**Circuit Board:** Connects electronic parts of laptop.
Motherboard: Heart of the laptop. A type of circuit board. Connects all components together so they can communicate. You can see copper lines or "conductive pathways" to allow communication between laptop parts. Often also have gold or nickel-gold to protect copper.	**Motherboard:** Heart of the laptop. A type of circuit board. Connects all components together so they can communicate. You can see copper lines or "conductive pathways" to allow communication between laptop parts. Often also have gold or nickel-gold to protect copper.

The Compositions of an iPhone

History:

- The iPhone was first announced by Apple on January 9, 2007. It is now on its 16 iteration, with 47 distinct models as of 2025.
- The iPhone that you may have in your hand is more than a complex smartphone – it is also a literal gold mine. And platinum mine. And silver mine, copper mine, aluminum mine, etc.

One iPhone requires 46 elements

Figure A-11. Handout materials for Kahoot/Trivia.

Can you name three of the top five materials used in an iPhone? (answers at the end)

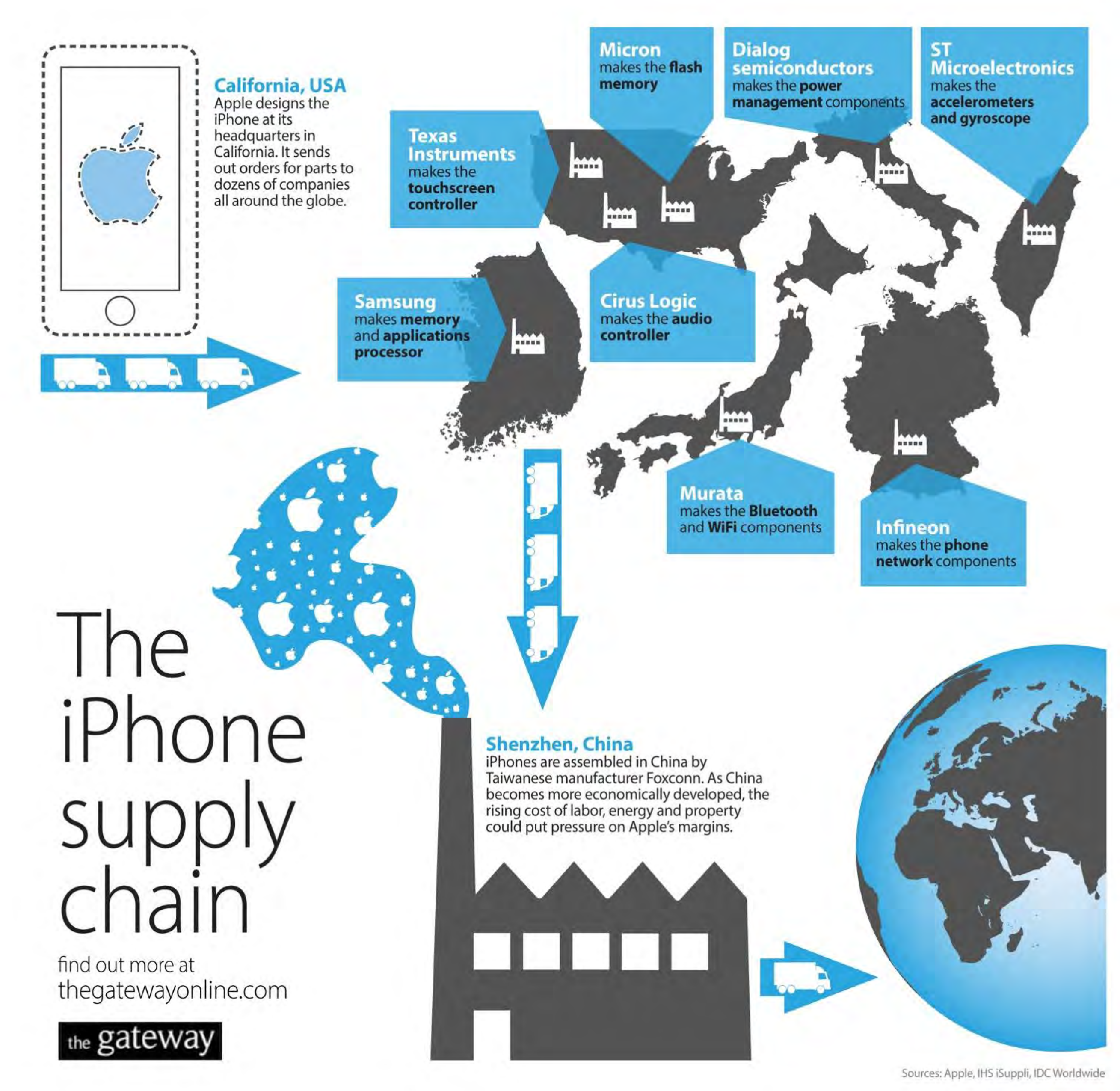
1. ______________________________
2.
3. ______________________________

Most minerals used in the creation of an iPhone are mined from these highlighted countries.

1. **Aluminum** is extracted from an ore called bauxite. The global reserves of bauxite are substantial, with countries like Australia, China, and Brazil leading in production. Significant deposits are also found in regions such as Jamaica and Vietnam.[2] Aluminum is a recyclable material, and different steel production methods often use recycled aluminum to create crude steel.
2. **Iron** is extracted from iron ore. Australia and Brazil dominate the world's iron ore exports, each having about one-third of total exports.[3] Iron has a variety of important uses, including being crucial in the production of steel made in a blast furnace.
3. **Gold** mainly comes from the United States, from five states in particular – Nevada, Alaska, California, Colorado, and South Dakota. Nevada has the highest gold production, accounting for nearly 75% of the total production the U.S.[4] Gold is used in phones and electronics because it is highly resistant to corrosion and is an effective conductor of electricity.
4. **Lithium** is the primary component of lithium-ion batteries. These batteries charge faster and last longer, with a high-power density in a lighter package than other battery options. Most of the world's lithium production comes from underground pools in Chile.[5]
5. **Copper** mainly comes from Chile,[6] with Peru in second place. There are about 6 grams of copper in an iPhone as it conducts heat and electricity very efficiently. Copper is also crucial to internal circuitry and wiring applications in general.

[2] https://www.ebsco.com/research-starters/geology/aluminum-deposits
[3] https://www.usgs.gov/centers/national-minerals-information-center/iron-ore-statistics-and-information
[4] https://nationaldiamond.com/blog/2024/Oct/02/ca-and-ak-have-most-gold-bearing-locations-nv-prod/
[5] https://globalcenters.columbia.edu/news/journey-through-chiles-lithium-landscape
[6] https://www.weforum.org/stories/2022/12/which-countries-produce-the-most-copper/

Component Manufacturing/Final Assembly



While Apple designs iPhones in the United States, their manufacturing and assembly processes occur across the world. As of 2021, iPhones use components from 43 different countries, including Japan, South Korea, Germany, France, Israel, Mexico, and more. The infographic on the previous page shows where different companies construct different iPhone parts. Once all the separate parts are created, final assembly occurs in a few different factories across the globe. Roughly 80% of iPhone assembly occurs in Shenzhen, China, in a factory owned by the Taiwanese company Foxconn. While Apple aims to shift the majority of its production to India in the coming years, odds are high that the iPhone in your pocket came from the Longhua Science and Technology Park in Shenzhen.

After the iPhone is fully assembled and ready for sale, it is shipped across the Pacific Ocean to Cupertino, California, for packaging and distribution. There are Apple distribution centers all over the world, which extends Apple's already highly complex supply chain even further. More than half of all Apple stores in the world reside in the United States, with the rest spread out over 24 different countries. From mining to consumer purchase, supply chain management and critical material security are crucial for the creation of one of the most popular devices in the world.

Discussion:

In pairs or groups of four, discuss the following ideas with your classmates:

1. What are some of the benefits and drawbacks of interconnectedness due to advances in technology?
2. How many people/how many hours do you think it takes to assemble one iPhone?
3. Which components in an iPhone contain critical materials?

Answer to the top five materials used in an iPhone:

- Aluminum (Al)
- Iron (Fe)
- Lithium (Li)
- Gold (Au)
- Copper (Cu)

Acknowledgment:

This presentation and activities are intended solely for educational purposes. It serves as an introductory resource for lessons, activities, and discussions related to e-waste recycling. Topics linked to this presentation can be explored through multiple science and engineering fields.

Sources:

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