XPLORLABS® *LifeSmarts* Lesson Plan
XPLOR Portable Electrical Power

INTRODUCTION

Safety engineering protects consumers by developing solutions and reducing risk through scientific investigation. Explore the safety of lithium ion batteries which are widely used as a source of electrical power in common consumer products.

SNYOPSIS

From cell phones to laptops and electric cars to hoverboards, portable electrical power and lithium ion batteries are part of students' lives every day. They're also the result of scientific inquiry and engineering. Learn about safety engineering and lithium ion batteries, and the phenomenon of thermal runaway; then transform that knowledge into a PSA to educate others about consumer safety.

QUESTION

What problems and/or challenges are posed by the wide use of lithium ion batteries?

PORTABLE ELECTRICAL POWER XPLORLABS LESSON

Materials:

1. *Portable Electricity* Pretest/Posttest
2. *Portable Electricity* Vocabulary Worksheet
3. *Portable Electricity* Vocabulary Worksheet Key
4. *Portable Electricity* Discussion Questions
5. *Portable Electricity* Discussion Question Prompts
6. *Portable Electricity* PSA Rubric
7. *Quizlet* Vocabulary Review: https://quizlet.com/367975842/portable-electrical-power-flash-cards/

Before the presentation: Check equipment and streaming video segments.

XPLORLABS RESOURCES

VIDEO	TITLE	LOCATING URL	LENGTH
Overview	XPLOLABS	https://watch.cloudflarestream.com/2d901122c148021a6515aaaf41544d90	0:55
Part 1	Intro to Portable Electrical Power	https://watch.cloudflarestream.com/ce62010d5b5dcb3c6b85ac139d0adbe8	2:48
Part 2	Intro to Thermal Runaway	https://watch.cloudflarestream.com/1158e3959bc1ab33eca4e9f95e5d80c0	1:05
Part 3	Understanding Safety Engineering	https://watch.cloudflarestream.com/f75217ba4208da019a04aa13de924584	0:35
Choose an Experiment	Crush Test	https://watch.cloudflarestream.com/338aab322e8bd38a667ffdbf7d758d57	0:55
	Blunted Nail Test	https://watch.cloudflarestream.com/65d7d334134919fc236ed99f32a1392e	0:52

VIDEO	TITLE	LOCATING URL	LENGTH
Choose an Experiment	Projectile Test	https://watch.cloudflarestream.com/9894275304aafc12c98046faf990f4a4	1:08
	Abusive Overcharge Test	https://watch.cloudflarestream.com/ab917adf7d07b898ae1853b7f9e6c10b	1:03
Part 4	Safety Engineering and You	https://watch.cloudflarestream.com/b2febcff5621f021123c726d39cb5e03	0:43
PUBLIC SERVICE ANNOUNCEMENT TUTORIAL			
RESOURCE		LOCATING URL	
PSA Source: *What is a PSA, Let me Learn site by the Joseph H Wade Junior High School*		https://sites.google.com/a/pacek-8.org/psa-step-by-step/home	

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LESSON PART ONE			
Duration	Activity	Leader Detail	Lesson Questions/Prompts/Notes
3 minutes 3/3	Overview Video	Play the XPLORLABS Introductory video. You may wish to play it a second time.	The video states that scientific exploration is an attitude. What do you think that means? Understanding science is a process. Being curious and understanding scientific principles is one way of looking at the world.
10 minutes 10/13	Pretest	Individual students complete the Pretest on the LifeSmarts Website.	The Pretest scores may be used to compare with Posttest scores at the end of the lesson.
10 minutes 10/23	Vocabulary Worksheet Discussion	Group participants into working teams of two or three. Distribute worksheet, review vocabulary definitions and ask teams to listen carefully for the definitions of the words listed. Most of the words will be defined in several short video clips.	Terms are explained in the lesson videos.
3 minutes 3/26	Video Part 1 Intro to Portable Electrical Power	Use the *Portable Electricity* Vocabulary Worksheet Key for vocabulary understanding after each video section.	Why are lithium ion batteries so popular? They hold more energy and charge and have a pretty long shelf life. What is the basic anatomy of the lithium ion battery – what are the component parts? Anode (negative electrode), cathode (positive electrode), lithium metal oxide (for the cathode), lithiated carbon (for the anode), and a separator
3 minutes 3/29	Video Part 2 Intro to Thermal Runaway		NOTE: If needed, you can watch this video twice to fully understand concepts presented. What is produced when the separation between the positive and negative electrodes break down and the chemicals mix like crazy? Heat If the battery gets punctured or crushed and the separator gets damaged the chemicals really start acting up – burning, melting, popping and in extreme cases exploding – what is that phenomenon called? Thermal Runaway

2 minutes 3/32	Video Part 3		What is a safety engineer's job? Safety engineers test the use and misuse of products in a controlled environment, like a laboratory. They test how products might react during use.
Battery Labs. BUT FIRST, UL wants us to tell you that these experiments have been conducted by a trained professional. The batteries have been tested in a controlled environment with the intent to fail. DO NOT try this at home or at school. At UL, safety engineers push batteries to the extreme! Next, we are going to watch 4 real experiments conducted in the UL laboratory.			
5 minutes 5/37	Crush Test	First up is the Crush Test. Let's see how a battery will respond to extreme force! Discuss test results.	Why do scientists test batteries? So they know how batteries will react to conditions in the real world.
	Blunted Nail Test	In the Blunted Nail Test the lithium ion battery is punctured! Discuss test results.	What happens when a battery is damaged by an internal short circuit and why is that dangerous? The damaged battery can go into thermal runaway. It is dangerous because not only can the battery-powered device catch on fire or explode, it could also cause a chain reaction setting off other batteries in the pack and destroying it and everything else around!
5 minutes 5/42	Projectile Test	Will an exploding battery spread fire on a large scale in the Projectile Test? Don't know – well let's find out! Discuss test results.	The Projectile test exposes a battery to a flame so the effectiveness of the cell pressure relief mechanism can be tested. Why is that so important? Sometimes batteries are exposed to fire, this test makes sure that the cell pressure relief mechanism will release the pressure inside the battery when it starts to overheat and hopefully prevent an explosion; it reduces the chance of a battery exploding.
	Abusive Overcharge Test	The last test is called Abusive Overcharge – did you know that a lithium ion battery could be overcharged? We just learned about the cell pressure relief mechanism, let's see how this test shows us more about overcharging lithium batteries. Discuss test results.	What could happen if you mismatched a charger to an electronic device? If the charger puts out more power than the battery can handle, the device could heat up quickly. Lithium ion batteries cannot accept overcharges. Lithium ion batteries and their chargers are specifically designed to work together.

Duration	Activity	Leader Detail	Lesson Questions/Prompts/Notes
5/47	Part 4 Safety Engineering and You	Portable electrical power and lithium ion batteries are part of your lives every day. They are also the result of scientific inquiry and engineering. These tests have shown you how safety scientists and engineers use scientific inquiry to examine and analyze thermal runaway causes to better understand how lithium ion batteries react to heat conditions, which is important because all lithium ion battery safety issues involve heat generation. Check student definitions of safety engineering and scientific inquiry. Discuss their importance.	Think about this – how many battery-powered devices do you use? Suggestions: cell phones, tablets, laptops, remote controls, even electric toothbrushes! How is scientific inquiry used to engineer a solution? First you ask a question, then do your research, from there make predictions, test predictions, then experiment. Are the predictions correct, or wrong, why? Track the data and analyze it. Form a conclusion. Is the original hypothesis right or wrong? Why? The process of scientific inquiry is a cycle, findings lead to more questions and ideas –engineering a solution or redesign is a result of that process.
		Optional Reinforcement Activity	Create Scientific Inquiry flash cards to help students remember and order the process. • Ask a question • Do the research • Make predictions • Do the test/ • Track/Analyze the Data • Form a Conclusion • Check your findings – was your hypothesis correct or incorrect? Distribute the cards to student volunteers and have the group place them in the correct order.
5/50	Review Vocabulary	Project Vocabulary Key. Ask students to share additional information they have added to their Vocabulary Worksheet.	

15/65	Discussion Questions	Distribute Discussion Questions to teams. Allow time for teams to discuss and write answers. Follow with group discussion.	See *Discussion Question Prompts*
LESSON PART TWO			
Duration	Activity	Leader Detail	
15 minutes	Posttest	Ask participants to complete the Posttest on the LifeSmarts Website. Compare posttest with pretest scores.	
60-90 minutes	How to create a PSA	Distribute PSA Rubric to large group and explain. Review step-by-step instructions to create a PSA NOTE: If time does not allow you to review the steps to create a PSA, assign this step as homework Preview several PSAs from the Resource Website	
60 minutes	Create PSA	Divide participants into groups of three or four. Groups will use the PSA learning site as a resource as they create their own 60-second PSAs. Potential Topics: *Safety & Portable Electrical Power* *Safety & Lithium ion Batteries* *Safety & Electronic Devices* *How to care for your electronic devices* *Are you misusing that battery?* Suggested Topic: *Safety & Portable Electrical Power* Post your final PSA at: https://lifesmarts.org/xplorlabs-video-form/	
ADDITIONAL ACTIVITIES		The Bologna Test—An Experiment See the energy in a battery expressed as heat and why button batteries are dangerous to small children. When swallowed, these button cell batteries can get stuck in the throat and cause severe burns. https://ulxplorlabs.org/experiments/the-bologna-test/ Read about Dr. Pravinray Gandhi, A Heart for Safety https://news.ul.com/news/mind-numbers-heart-safety Listen to Judy Jeevarajan talk about how she is helping make the world safer through her extensive study and research of batteries https://watch.cloudflarestream.com/fa9df5a07ef27f9807045034e4ec5f07	
		Provide students with links to access the UL XPLORLABS educational platform where they can "solve through science" with more interactive videos, instructional experiences, hands-on activities and creative challenges! https://ulxplorlabs.org/all-modules/	

	Showcase group PSAs with a "screening." Make popcorn; invite parents or another class
	Obtain permission to play PSAs in teacher lounges and/or on student hall televisions
	Encourage teams to share PSAs with local grocery stores, department stores, and big box stores, possibly local radio or TV stations
	Quizlet Study Tool: https://quizlet.com/367975842/portable-electrical-power-flash-cards/

XPLORLABS® *LifeSmarts* Discussion Questions
XPLOR Portable Electrical Power

With innovation comes risk. When a new invention is created, the world is often unaware of the dangers or risks associated with the new technology. Electricity is a great example of this concept. When electricity was first introduced at the World's Fair it posed a major fire and electrocution hazard to buildings and people. Through science-based research, we began to understand that electricity, when handled and installed properly, greatly improves peoples' quality of life. Electricity's fire and electrocution risks were mitigated through new safety standards.

Remote controls, singing greeting cards, tablets, cell phones, and even electric vehicles – lithium ion batteries power the products people use and rely on. Safety Engineers follow a set of safety standards when evaluating electronic devices that use lithium ion batteries. A critical concern is that a small percentage of lithium ion batteries experience internal short circuits that result in thermal runaway – the rapid buildup of heat within the battery that leads to the explosive release of energy or fire.

Answer the following questions using this scenario: Your friend just got a cool new hoverboard, but you recently read a story about hoverboards being dangerous and a fire risk and you just learned about how lithium ion batteries can go into thermal runaway. You want to be excited for your friend, but also want your friend to be safe.
Share all the devices you can think of powered by lithium ion batteries used by you, your family and your friends.
Draw or list the parts of the inside of a lithium ion battery.
Share or draw what you learned about the phenomenon of thermal runaway.

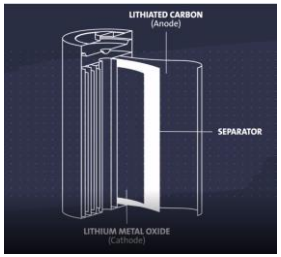
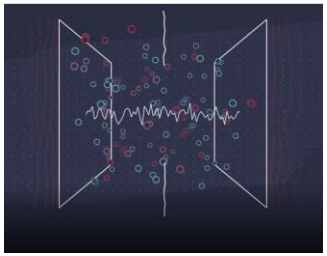
XPLORLABS® *LifeSmarts* Discussion Questions
XPLOR Portable Electrical Power

Help your friend be an informed consumer by making a Pro and Con list, highlighting why it is important to understand the way lithium ion batteries work.
Make a compelling argument convincing your friend that safety engineering and safety standards help make lithium ion batteries safer for consumers.

XPLORLABS® *LifeSmarts* Discussion Question Prompts
XPLOR Portable Electrical Power

See above please ☺ Remote controls, singing greeting cards, tablets, cell phones, and even electric vehicles – lithium ion batteries power the consumer products we use and rely upon. We check the power status and charge our devices without even considering the possible safety concerns these batteries may pose. Safety engineering and safety standards allow consumers to use numerous electronic devices worry free. However, thermal runaway, a battery hazard which happens infrequently, can have serious consequences.

Understanding how safety engineering and safety standards helps reduce the likelihood of thermal runaway is part of being a safety smart consumer.

Share all the devices you can think of powered by lithium ion batteries used by you, your family and your friends. Answers will vary. Possible answers include watches, remote controls, digital cameras, cell phones, remote car locks, electric cars, tablets, laptop computers, solar panels, MP3 players, calculators, electric wheelchairs, singing greeting cards, toys, flameless candles, etc.
Draw or list the parts of the inside of a lithium ion battery.    Anode (negative electrode); Cathode (positive electrode); Separator (divides anode and cathode but allows ions to move from side to side)
Share or draw what you learned about the hazard of thermal runaway.  When the separator in a lithium ion battery breaks down, the chemicals in the battery mix. This generates more and more heat, leading to popping, burning, and in some cases, explosions. Incidents of thermal runaway are frequently reported in the news. Examples of devices that have caught fire include hoverboards, computers, children's battery powered vehicles and cell phones.

XPLORLABS® *LifeSmarts* Discussion Question Prompts
XPLOR Portable Electrical Power

Help your friend by making a Good vs Bad list highlighting why/why not being an informed consumer includes understanding the way lithium ion batteries work?

It is important to understand safety measures one can take to keep and use devices safely. Knowing what could damage a battery and lead to thermal runaway is part of using battery-powered devices safely.

PRO	**VS**	**CON**
Helps keep me, my family and friends safe		The people closest to me could get hurt
I use electronic devices correctly		Electronic devices could be used incorrectly and thermal runaway might be the result
I can teach others how to use electronic devices safely		If I don't teach others, who will?
It's my responsibility as a good consumer advocate and share my safe battery knowledge		Understanding the safety measures and not sharing the knowledge

Make a compelling argument convincing your friend that safety engineering and safety standards help make lithium ion batteries safer for consumers.

Battery designs that are tested to safety standards help make products safer for consumers. Using scientific investigation, experiments and tests, safety engineers identify the hazards of lithium ion batteries and reduce the risks by developing solutions to problems, like thermal runaway.

XPLORLABS® *LifeSmarts* Vocabulary Key
XPLOR Portable Electrical Power

Vocabulary Term	Definition
anode	The negative electrode
battery	A device that converts chemical energy into electrical energy
button or coin cell battery	Lithium cells shaped like buttons or small coins that power small electronic devices such as remote controls or garage door openers
cathode	The positive electrode
chargeable battery	A battery that can be discharged and then recharged, it is not discarded after a single use
coin cell battery	See button cell battery
electrode	One of the two points where electricity is flowing in or out of a battery
electrolyte	A liquid or gel that conducts electricity
EV	Electric vehicle
lithium-ion battery	A battery that works by lithium ions moving from the negative electrode (anode) to the positive electrode (cathode) during discharge
lithium-ion battery pack	An assembly of multiple batteries
portable electric power	Electrical power that can be brought with you
safety engineering	Identifying hazards and reducing risks by developing solutions informed by scientific investigation, study, experiments and tests
safety standards	Written documents that outline the process in which a product is tested to help mitigate risk, injury, or danger
scientific inquiry	Investigation to gather and analyze data, construct arguments from evidence, and communicate findings
separator	A thin porous membrane that divides the anode and cathode while enabling the exchange of electrically charged ions from one side to the other
thermal runaway	A rapid, uncontrolled increase in temperature causing additional increases in temperature, usually resulting in a hazardous situation

PLORLABS® *LifeSmarts* Vocabulary Worksheet
XPLOR Portable Electrical Power

Vocabulary Term	**Definition**
anode	
battery	
button cell battery	
cathode	
chargeable battery	
coin cell battery	
electrode	
electrolyte	
EV	

PLORLABS® *LifeSmarts* Vocabulary Worksheet
XPLOR Portable Electrical Power

lithium-ion battery	
lithium-ion battery pack	
portable electric power	
safety engineering	
safety standards	
scientific inquiry	
separator	
thermal runaway	