Potential Dangers Associated with Lithium-ion Batteries

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Introduction

As educators, we are constantly reminded of education's ever-changing nature. In the past few years, educators have had to learn how to teach remotely, become more aware of their students' social and emotional needs, address new standards and requirements, and develop safety protocols to keep everyone safer in an intruder-based emergency. Now, a new safety concern is being recognized as a threat to safety in our society involving the use and storage of Lithium-ion (Li-ion) batteries. This serious safety threat must be addressed in our schools.

Reason for the Concern

Educational leaders must provide a standard or duty of care for their school's students, teachers, and staff to keep everyone safer in a science/STEM environment (*Why You Should Care About the Duty of Care*, 2022). To do so, educational leaders must be aware of the inherent dangers in their instructional and other associated spaces, equipment, and activities. This gets complicated when the materials students use are assumed to be safe, such as the tablets, smartphones, computers and other equipment. These devices are among those that are dangerous because of the energy sources used to power them.

Educators need to learn the dangers of the Li-ion batteries we use today, mainly because they have not been made aware through safety training or professional development. Though we use these batteries to provide a more environmentally friendly power source (*Environmental Impacts of Lithium-ion Batteries | UL Research Institutes*, n.d.), they are potentially highly dangerous, especially when improperly used, stored, or charged. Even though educators must know the dangers before introducing equipment into the instructional space, most do not recognize Li-ion batteries as a cause for concern.

Since society started using these batteries as an alternative power source, they have caused fires that destroyed property, injured, and even killed people. Some of these resulting fires were caused by batteries used in small devices that were improperly stored, forgotten about, and subjected to heat for long periods of time (Chibe, 2023). Li-ion batteries are prone to causing fire if they are old, damaged, or improperly maintained[1]. The danger is not only in the battery, but in how we store the devices. There may be many devices that administrators/supervisors have in their schools that use Li-ion batteries that they are not aware of. These items need to be located and they need to be properly stored and maintained.

Lithium-ion batteries are already found in many devices in our schools, such as smartphones, cameras, computers, drones, electric cars, powered toys, battery chargers, etc. (Kelleher, 2023; Hartman et al., 2018). Even professional laboratories are not immune to fires caused by the Li-ion batteries found in electronic devices (Jones, Weiland, Mitterer, et al., 2023). They are also responsible for fires on airplanes[2]. These batteries are found in old and discarded equipment that were forgotten about until they ignited a fire[3].

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[1] https://www.osha.gov/sites/default/files/publications/shib011819.pdf
[2] https://explore.dot.gov/#/site/FAA/views/LithiumBatteries/IncidentDetails
[3] https://www.science.org/content/blog-post/after-fire

Lithium-ion batteries are growing in popularity, and their increased use is a cause for concern (Jaguemont & Bardé, 2023). Government agencies are starting to learn about their dangers and taking steps to protect their people. The United States Post Office has changed its protocols and taken steps to limit and prohibit the shipment of equipment with Li-ion batteries (Coleman, 2023). Because of their growth in popularity, schools must prepare to handle emergencies caused by Lithium-ion batteries and administrators/supervisors must train their staff on how to handle such emergencies. The following sections will review Lithium-ion batteries as a power source, OSHA Safety & Health Information, and safety protocols that should be adopted to keep students, staff and instructional sites safer.

I. Lithium-ion Batteries as a Power Source

As noted in the article "Are lithium and lithium-ion batteries the same?" (https://www.ufo-battery.com/are-lithium-and-lithium-ion-batteries-the-same), be aware that the lithium battery was commercially available in the early 1970s, when the lithium metal was not stable in the charging process. Debuted in 1991, the lithium-ion battery replaces the existing heavier and less efficient rechargeable batteries. The types of cells used by the lithium and lithium-ion batteries are different, and the former is the primary cell while the latter is secondary cell. That is to say, lithium is used in the metallic form for the lithium battery. This is why the lithium-ion battery is rechargeable and the degrading process can be later after being recharged many times. Lithium battery cannot be easily or safely recharged, which result in the invention of the lithium-ion battery.

Lithium-ion batteries have played an increased role in Science/STEM activities in recent years. The upside is students have more opportunities to engage in hands-on activities using modern technology at a younger age. These batteries store tremendous energy in a small space, and most can be recharged. The downside is the batteries can overheat and become a hazard in the Science/STEM instructional spaces (Jaguemont & Bardé, 2023). The fires that the overheated batteries cause are more difficult to put out than common fires[4].

Schools making use of lithium-ion batteries as power sources must provide teachers and staff with the necessary training to handle potential safety hazards and resulting health and safety risks related to these types of batteries along with appropriate safety actions. The appropriate safety protocols are based on legal safety standards and better professional safety practices to be better prepared for the inherent dangers lithium-ion batteries pose and how to handle them when they do occur.

It is essential to understand that the danger posed by Lithium-ion batteries is not isolated to materials purchased by schools. Administrators and supervisors need to be aware that students and staff may bring devices into the school building that use Lithium-ion batteries. All staff must be trained to identify these potential safety hazards and handle the resulting emergencies should they occur. A good resource to find out more about the dangers of Lithium-ion Batteries is the

[4] https://www.axios.com/2023/03/31/battery-fires-regulation-new-york-city-lithium-ion [4]

article titled “A Critical Review of Lithium-Ion Battery Safety testing and Standards” by Jaguemont & Bardé.

Please note that in the case of a fire, smoke, etc., if the emergency situation cannot be handled or if there are any doubts about employee’s ability, activate the fire alarm and follow the school’s procedures for exiting the building. When in doubt, get out!

II. OSHA Safety & Health Information Bulletin: Lithium-ion Batteries

In 2019, OSHA issued a Safety and Health Information Bulletin titled “Preventing Fire and/or Explosion Injury from Small and Wearable Lithium Battery Powered Devices.” (https://www.osha.gov/sites/default/files/publications/shib011819.pdf) According to this bulletin, in February 2018, the U.S. Consumer Product Safety Commission’s Status Report on High Energy Density Batteries Project reported over 25,000 overheating or fire incidents involving more than 400 types of Lithium-ion battery powered consumer products that occurred over a five-year period.

OSHA also noted that damage to Lithium-ion batteries can occur immediately or over a period of time, from physical impact, exposure to certain temperatures, and/or improper charging including the following:

- *Physical impacts that can damage lithium-ion batteries include dropping, crushing, and puncturing.*
- *Damage to all types of lithium-ion batteries can occur when temperatures are too high (e.g., Above 130°F). External heat sources (e.g., open flames, heaters, etc.) can also accelerate failure in cells with defects or damage from other causes.*
- *Damage to lithium-ion batteries can occur when the batteries themselves or the Environment around the batteries is below freezing (32°F) during charging. Charging in temperatures below freezing can lead to permanent metallic lithium buildup (i.e., plating) on the anode, increasing the risk for failure.*
- *Charging a device or battery without following manufacturer’s instructions may cause damage to rechargeable lithium-ion batteries. For example, some manufacturer-authorized chargers will cycle the power to the battery on and off before it is fully charged to avoid overcharging. Since ultra-fast chargers may not cycle power, do not use them unless the manufacturer’s instructions include them as an option.*

OSHA also recommends the following training components for safety use of lithium-*ion* -powered devices, cells or batteries in the workplace:

Ensure that workers who use or handle lithium-*ion* -powered devices, cells, or batteries in the workplace receive training associated with these products, including training on how to:

• Verify NRTL certification for batteries, chargers, and associated equipment, where applicable.
• Identify defective, damaged, or failing lithium-ion-powered devices and batteries.
• Remove defective devices or batteries from the workplace.
• Quickly remove a lithium-ion-powered device from clothing if it feels hot or if the device is leaking, releasing gas, hissing, bulging/cracking, or on fire.
Ensure that an emergency action plan (EAP) for a workplace with lithium-ion -powered devices or batteries includes lithium-ion -related incident response procedures based on manufacturer's instructions for responding to battery failures including fires and/or explosions.

Employees need to immediately contact their building administrator or supervisor if they cannot locate their EAP.

III. Safety Protocol for Lithium-ion Batteries

The following safety protocol are recommended for lithium-ion batteries:

- Inspect the lithium-ion batteries for damage or defects prior to using in the instructional space.
- Lithium-ion batteries should have a designated storage area with a door that closes[5]. These areas should be dry and within the recommended temperature range per the manufacturer's specifications.
- Review state and local fire codes for storing and using lithium-ion batteries with your fire marshal.
- Only purchase lithium-ion batteries or devices with lithium-ion batteries once you are prepared to store them and your staff has been trained on how to use them, how to dispose of them safely, and how to handle them in an emergency situation.
- Check the manufacturer's instructions for handling, storing, using, and maintaining lithium-ion batteries, including when they overheat. This information should be learned before a school decides to purchase the equipment.
- Have the appropriate engineering controls, as per the manufacturer's recommendations and local guidelines, in place.

[5] https://infohub.nyced.org/in-our-schools/operations/lithium-ion-battery-safety#:~:text=Lithium%2Dion%20batteries%20are%20not,with%20a%20door%20that%20closes.

    - As per the manufacturer's recommendations, have the appropriate fire extinguisher in case of emergency.
        - The required fire extinguisher may include an ABC or a Class-D Fire Extinguisher. If you do not have the appropriate fire extinguisher, do not purchase, store, or use a lithium-ion battery.
- Only purchase batteries that a Nationally Recognized Testing Laboratory[6] has tested[7].
- Keep away from heat sources.
- Do not allow the batteries to be exposed to freezing temperatures (<32°F)
    - Do not leave them in the car during the winter.
- Only charge batteries and devices following the manufacturer's instructions.
    - Train staff and students on how to use the batteries and devices accordingly.
- Do not overcharge.
- Do not use damaged batteries.
- Only use the charger intended for the specific battery you are charging[8].
- Make sure your district and school emergency plans include how to handle, store, use, and maintain Lithium-ion Batteries.
- Do not charge the batteries overnight.

IV. Chargers and Charging Practice

The University of Washington's Department of Environmental Health & Safety has provided safety protocols for on chargers and charging practice for Lithium-ion batteries. (https://www.ehs.washington.edu/system/files/resources/lithium-battery-safety.pdf) as follows:

• Never charge a primary (disposable lithium-ion or alkaline) battery; store one-time use batteries separately.
• Charge or discharge the battery to approximately 50% of capacity before long-term storage.
• Use chargers or charging methods designed to charge in a safe manner cells or battery packs at the specified parameters.
• Disconnect batteries immediately if, during operation or charging, they emit an unusual smell, develop heat, change shape/geometry, or behave abnormally. Dispose of the batteries.
• Remove cells and pack from chargers promptly after charging is complete. Do not use the charger as a storage location.

[6] https://www.osha.gov/nationally-recognized-testing-laboratory-program
[7] https://www.osha.gov/sites/default/files/publications/shib011819.pdf
[8] https://www.nfpa.org/-/media/Files/Public-Education/Resources/Safety-tip-sheets/LithiumIonBatterySafety.ashx

• Charge and store batteries in a fire-retardant container like a high quality LiPo Sack when practical. (https://www.dslrpros.com/dslrpros-blog/why-lipo-bags-are-essential-for-battery-safety/)

• Do not parallel charge batteries of varying age and charge status; chargers cannot monitor the current of individual cells and initial voltage balancing can lead to high amperage, battery damage, and heat generation. Check voltage before parallel charging; all batteries should be within 0.5 Volts of each other.

- Follow all manufacturer's guidelines for charging Li-ion batteries.

• Do not overcharge (greater than 4.2V for most batteries) or over-discharge (below 3V) Batteries. Check the manufacturer's guidelines for more information.

V. What to Do if a Lithium-ion Battery is Overheated or Damaged

- Place the battery in a fire-resistant container and cover it with sand or any other manufacturer-recommended extinguishing agent.
- If the Lithium-ion battery smokes, catches fire, or explodes, activate the fire alarm and follow your school's or district's procedure for exiting the building.
- Record the incident and submit it electronically to the appropriate administrator(s).
- Dispose of according to local and state regulations.

VI. Conclusion

Lithium-ion batteries are a great tool to help students learn about the world around them. Li-ion batteries can be used safely and effectively in the Science/STEM instructional spaces if followed by the correct protocols and training. It is imperative that the new technology is not incorporated into a school setting without ensuring that the schools have the proper facilities to store the batteries and the engineering controls to mitigate any potential hazards and resulting risks. School leadership needs to provide the necessary training on how to use, store, maintain Li-ion batteries and what are the appropriate protocols if one should show signs of overheating. Li-ion batteries are a great addition to the teaching/learning experience classroom if the proper precautions are taken to keep students and staff safer.

References

Chibe, M. (2023). Lincoln officials give safety warning after lithium batteries cause truck fire. *KLKN-TV*. https://www.klkntv.com/lincoln-officials-give-safety-warning-after-lithium-batteries-cause-truck-fire/?alert=2682927&alert_type=banner

Coleman, K. (2023, July 5). USPS is making these changes to your mail, starting Sunday. *Best Life*. https://bestlifeonline.com/usps-changes-july-9-

news/?utm_source=Iterable&utm_medium=email&utm_campaign=campaign_7204517&utm_source=nsltr&utm_medium=email&utm_campaign=etntNewsletter

Environmental impacts of lithium-ion batteries | UL Research Institutes. (n.d.). https://ul.org/research/electrochemical-safety/getting-started-electrochemica safety/environmental-impacts

Hartman, C., Brink III, E., & Bland, G. (2018). Safety Spotlight: Managing the Risks of Lithium Batteries in the Classroom. *Technology & Engineering Teacher*.

Jaguemont, J & Barde, F (2023), A critical review of lithium-ion battery safety testing and standards, Applied Thermal Engineering, 2023, 121014, https://www.sciencedirect.com/science/article/abs/pii/S1359431123010438

Jones, M.P., Weiland, K., Mitterer, C. *et al.* Insights from a laboratory fire. *Nat. Chem.* 15, 885–889 (2023). https://doi.org/10.1038/s41557-023-01254-6

Kelleher, S. R. (2023, March 3). FAA: Lithium Battery Incidents on Planes Now Happening More Than Once Per Week. *Forbes*. https://www.forbes.com/sites/suzannerowankelleher/2023/03/03/faa-lithium-battery-fire-smoke-airplane/?sh=57c78ddbbb04

Why You Should Care About The Duty of Care. (2022, June 8). Edwards, Stevens & Tucker, LLP. https://estattorneys.com/why-you-should-care-about-the-duty-of-care/

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