Chemistry Demonstrations That Should Not Be Done in the K–12 Instructional Space

I. Introduction

Consider the following all too common scenario: A chemistry teacher has reached the end of the school day. In planning for the next day's lesson, the teacher decides that a demonstration would reinforce and enhance the concept to be taught.

An online search produces lots of options, including some videos. The videos are engaging, and the demonstrations look easy enough to do. However, the experienced chemistry teacher knows that preparing and conducting a chemistry demonstration takes time and a lot of careful consideration.

First and foremost, what are the potential safety hazards and resulting health and safety risks? What products will be made, and how can they be disposed of properly? Will those products have to be stored until the next chemical disposal cycle?

As class sizes have increased since COVID, how will this impact the ability to conduct the demonstration more safely and with all students being able to see what is happening? Is the demonstration done to enhance instruction, or does it lean more toward entertainment?

While not unique to chemistry, many veteran teachers have left the classroom in the past few years. This loss of experience can be profoundly impactful for newer chemistry teachers. Many newer chemistry teachers lack the resource of that teacher down the hall who can detail the nuances and issues that could arise with a particular demonstration, offer advice, help with setup, and provide alternative, safer options.

It is also important to consider that write-ups or recordings of chemistry demonstrations may be easily accessible from unvetted resources. These resources often lack information such as the molarities needed or the mechanism behind the reaction.

Demonstrations from reputable sources should also be carefully considered. These sources often assume that an experienced chemist will do the demonstration with access to all safety equipment and an appropriate instructional space to perform the demonstration.

This safety issue paper lists demonstrations that should be avoided or evaluated based on potential safety hazards and resulting health and safety risks versus value. Keep in mind that this list is not comprehensive, and both newer and veteran chemistry teachers should be adequately and appropriately trained in chemical safety, storage, and regulations.

II. What has changed in the chemistry instructional space since COVID-19?

Even before the COVID-19 pandemic, safety issues in chemistry instructional spaces have been a concern (Sigmann 2018), and post COVID, K–12 chemistry instructional spaces have faced several challenges and shifts in educational practices. Notable changes include these.

1. **Lack of Safety Training for New Educators.** Many new teachers lack adequate training in essential safety protocols, posing potential safety hazards and resulting safety risks with handling chemicals and conducting experiments.

2. **Increases in Class Sizes.** Larger class sizes have become more common, making individualized instruction and safer oversight of laboratory activities more difficult (Flannery 2024).

3. **Lack of Hands-On Training.** The transition to virtual or hybrid learning during the pandemic reduced opportunities for practical, hands-on chemistry experiences, leaving students and new educators with gaps in essential skills. One report from 2022 shows that 35% of science teachers lack any safety training (EdCircuit Staff 2022).

4. **Unvetted Resources and Recommendations.** The rapid shift to online learning led to widespread reliance on unverified resources, which may not align with best practices or safety standards, compounding the challenges of maintaining quality instruction.

These factors underscore the need for a renewed focus on professional development, instructional space safety, and resource vetting to support educators and ensure effective chemistry education.

III. Examples of Specific Demonstrations to Avoid

The demonstrations listed below pose serious potential safety hazards and resulting risks due to toxic fumes, explosion risks, or uncontrolled reactions. They require advanced safety measures and are better suited for controlled, professional laboratory settings.

IIIa. Pre-Lab Procedures

- Do not allow bare feet and open-toed or perforated shoes.
- Remind students with long hair to use a hair tie.
- Be cognizant of both your clothing students' clothing. Scarves and flowy garments are not permitted. Loose clothing like a jilbab or chador can be worn if they don't interfere with the student's safety in the lab.
- Use indirectly vented chemical splash goggles or safety glasses with side shields meeting the ANSI/ISEA Z87.1 D3 standard when working with an open flame (aligned with ANSI/ISEA Z 113).
- Follow safety acknowledgment form rules. Students should not be seated during the lab.

IIIb. Demos to Avoid Due to Fire Hazards

Exploding Pumpkin

The carbide exploding pumpkin demonstration involves a reaction between calcium carbide and water, which produces acetylene gas. Acetylene is a highly flammable gas, and the fire hazard results from several factors.

- Flammable Gas. Acetylene has a wide flammable range, meaning it can ignite easily if mixed with the right amount of oxygen. Any spark, flame, or heat source can cause an explosion.
- Confined Space. The acetylene gas builds up inside the pumpkin. When ignited, the confined space creates a sudden and intense explosion. This also increases the risk of an uncontrolled fire or injuries from flying pumpkin fragments.
- Inadequate Ventilation. Acetylene is heavier than air and can accumulate in low areas if not properly ventilated. This creates a fire hazard.

Rainbow Lab

The Rainbow Experiment is a science activity that shows how burning different salts creates flames of different colors. This experiment often uses methanol. Unfortunately, over the years, many students and teachers have been seriously injured while doing this activity in school labs. The safety warnings and firefighting tips in the methanol Safety Data Sheet highlight these dangers. To make matters worse, some teachers have mistakenly poured methanol from their containers near an open flame, which can easily lead to dangerous accidents. Hill (2014) provides information about safe alternatives to this experiment, as does the information in this link.

Whoosh Bottle

The whoosh bottle demonstration involves igniting a small amount of alcohol inside a large plastic bottle to produce a dramatic "whoosh" sound and a bright flame (Sigmann 2018).

- Flammable Vapors. Alcohol vapors are highly flammable. If the bottle contains too much vapor or is improperly ventilated, the reaction can produce an unexpectedly large flame or explosion.
- Flashback. Alcohol vapors can ignite outside the bottle if there is a nearby ignition source, creating a risk of burns or other fires.
- Residual Alcohol. If leftover alcohol remains in the bottle, it can reignite when exposed to a flame or spark, posing a safety hazard and resulting health and safety risks after the demo appears to be finished.
- Inadequate Ventilation. Alcohol vapor can accumulate in enclosed spaces, increasing the risk of uncontrolled ignition or explosion.
- Use of Glass Bottles. The rapid pressure changes caused by the reaction can shatter glass bottles, creating flying shards that can cause injuries.
- Pouring Alcohol Near an Open Flame. Adding or pouring alcohol near the ignition source can lead to accidental ignition of the liquid or vapors.

Experiments Involving Cornstarch

- Flammability. Cornstarch is highly flammable in its powdered form. When ignited, it can burn rapidly, producing significant heat and flames.
- Dust Explosions. Dust explosions occur because the large surface area of the suspended particles allows for rapid combustion.
- Ignition Sources. Cornstarch used near open flames, Bunsen burners, or electrical equipment can ignite easily.
- Confined Spaces. If the cornstarch cloud is in a confined space, such as a container or enclosed lab area, the explosion risk increases due to rapid pressure buildup.
- Residual Dust. Leftover cornstarch dust on surfaces can accumulate over time, creating additional fire risks if not cleaned thoroughly.

Thermite Reaction

The thermite demo, involving the reaction between aluminum powder and iron (III) oxide, is known for its intense heat and the production of molten metal. The NSTA Safety Advisory Board urges all school districts to have thermite professionally removed from school campuses and to prohibit future purchases of the chemical.

- Extreme Heat. The thermite reaction reaches temperatures of more than 2,200°C and can melt metal and igniting surrounding materials.
- Molten Metal. The molten iron produced can splatter, ignite flammable materials, or cause severe burns.

- Uncontrolled Ignition. The reaction can ignite unexpectedly if exposed to heat. Sparks ejected can cause secondary fires.
- Flammable Gases. Some thermite mixtures may release flammable gases during the reaction, which can ignite secondary fires.
- Projectiles. Improper containment of the reaction can cause fragments of the reaction vessel to be ejected at high speeds.
- Secondary Fires. The heat can ignite nearby flammable objects, including paper, wood, or lab furniture.

Sulfuric Acid and Sugar

- Heat Generation. The reaction is highly exothermic, releasing significant heat. This heat can ignite nearby flammable materials or cause burns if improperly handled.
- Flammable Gases. The reaction may produce small amounts of combustible gases, including carbon monoxide, especially in confined spaces.
- Spill Risks. Spilled sulfuric acid could become a fire hazard.

IV. Conclusions

Safety in the K–12 chemistry laboratory space must always be a top priority. The demonstrations discussed in this paper highlight the potential safety hazards and resulting health and safety risks that can arise when safety is not thoroughly considered. As educators strive to make chemistry engaging and interactive, it is essential for them to prioritize demonstrations that are not only impactful, but also safer and appropriate for the classroom setting.

Future work of the SAB will include exploring specific types of demonstrations that should be unequivocally avoided due to safety hazards and resulting health and safety risks such as toxic fumes, explosion hazards, or inadequate safety training, which would further empower educators. The resources that result from this work would address the growing need for vetted, safer instructional practices, ensuring that chemistry education remains both inspiring and secure for all students.

V. Examples of Reliable Sources for Safe Chemical Demonstrations

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VI. Additional References

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