Safer Alternatives in Science Activities Workshop

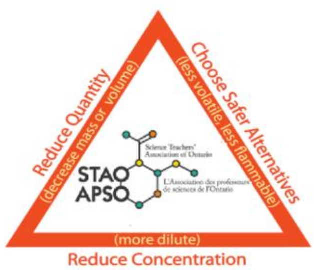
Intended Audience: All science teachers

Time: 60 – 90 min

Recommended Prerequisite: STAO's Hazard and Risk Workshop

Introduction:

This workshop is a logical continuation of the Hazard and Risk Workshop. Using safer alternatives is a key strategy to keeping risk to an acceptable minimum during science activities. In this workshop, participants are introduced to the STAO safety triangle which summaries a three-sided approach to safer activities:



Participants are provided with examples of activities common to the grades 9 and 10 curriculum, organized along the themes of the STAO safety triangle. They first see examples of how these activities are traditionally conducted, discuss the hazards and risks involved, and then are provided with safer alternatives.

After each theme or "side" of the safety triangle, participants break out into small groups to discuss the examples and share other safer alternatives. A member of each group captures these suggestions, preferably in an online document for sharing with colleagues.

"Safer Alternatives in Science Activities" is recommended as an essential component of the teacher safety training program because it promotes an attitude of science mindedness in the science program.

Preparation and Materials Required:

- Have a Google doc prepared for each discussion item outlined below so that group discussions are recorded and used to inform future practice. During the discussions, have the Google doc on the presentation screen so that participants can see the ideas being generated.
- Workshop evaluation form
- Materials for the Magic Milk activity
    - 1 L homogenized milk
    - Paper dinner plates
    - 1 Q-tip per group
    - One package of food colouring per group (e.g., 4 colours per package)
    - Small dropper bottle of liquid detergent

Suggested Strategies:

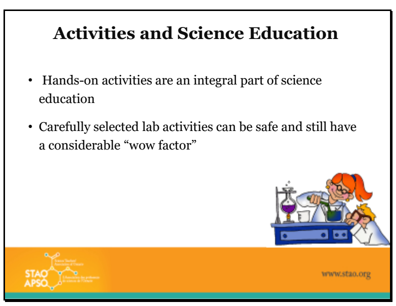
- Opener:
  The Magic Milk activity is a fun and engaging way to either “break the ice” at the beginning of the session or as a fun break halfway through the session. This activity shows that science activities can have plenty of “wow” factor without having to rely on pyrotechnics to engage students.
  Alternatively, participants could be asked to share some of their “scariest” demo moments and identify the factors that made these events risky.
- After covering the “Reduce Quantities” examples, ask participants to form small discussion groups and share their thoughts on these examples and other ways they have found useful to “Reduce Quantities”.
- Repeat the previous bullet for both “Choose Safe Alternatives” and “Reduce Concentrations”.

Slide Notes

Slide 1

Selecting safer alternatives is an important strategy in minimizing risk to injury while maintaining an engaging science program. This module introduces several examples of safer alternatives and stimulates discussion to identify more.

Slide 2



It’s hard to imagine a science program without hands-on activities. These activities bring science to life, engage students, and serve as a natural springboard or context for learning. You don’t need pyrotechnics to engage and excite students. This module introduces several safe activities with plenty of “wow” factor to engage students.

Slide 3

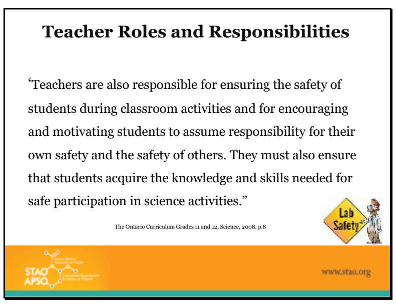
There is no reason a science class cannot be both safe and fun. However, this requires a great deal of planning. Book for the expected and unexpected things can happen, use a great deal of common sense, and ongoing training.

Relying on common sense when planning science activities may seem obvious. However, what's common sense to one science educator may not be to another. That's why it's so important to discuss activity ideas and test them with colleagues, prior to conducting the activity.

Slide 4

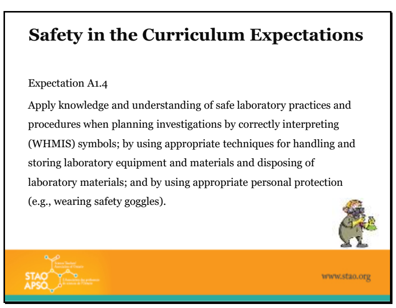
"Magic milk" is an excellent example of a safe activity with plenty of wow factor. If time permits, conduct the activity with the group rather than just showing the video. In small groups, ask them to consider how they would use this activity in their courses. One suggestion is to use it on the first day of school and ask students to design a controlled experiment in which they investigate the effect of milk fat and the rate of spreading of colour. This would require the teacher having different varieties of milk available, e.g., homogenized, skim, cream. As long as the activity is done without glassware, no significant safety training is required. This is an excellent strategy to get kids excited about science and to set the tone for what science class will be like for the coming year.
Source: https://youtu.be/pW-bn9zssak

Slide 5



The science curriculum clearly states that promoting safety is a key role and responsibility of the classroom teacher. This implies that the teacher sets the tone for safety by providing clear and logical expectations and by modeling best practices. Having students take an active role in their safety and that of others promotes a culture of safety mindedness in the school.

Slide 6



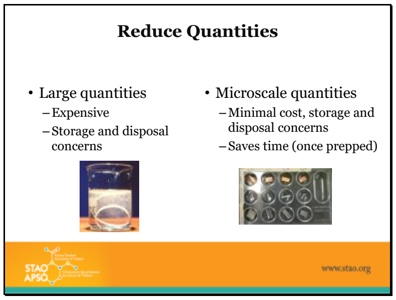
Demonstrating their understanding of safety and best safety practices is a curriculum expectation in every science course. This expectation implies that teachers assess and evaluate safety. It is also recommended that teachers maintain a record of their safety training.

Slide 7

The STAO safety triangle is an excellent metaphor that summarizes a three-pronged approach to reducing risk in the activities you conduct:

- reducing the quantities of chemicals used,
- choosing safer alternatives,
- and reducing the concentration where possible.

Slide 8



Reducing quantities is one of the simplest ways of minimizing risk in activities. The speaker on the left contains a strip of magnesium metal reacting with HCl to release hydrogen gas. This works well as a teacher demonstration. But after the demonstration, the teacher must deal with the disposal of the waste acid. Conducting the activity on microscale level, such as illustrated on the right, greatly reduces the volume of acid required. Furthermore, it also allows the activity to be conducted by students, getting them more engaged in their learning. Microscale activities may require more prep time initially, but once put together in small kits, they become a very convenient way of conducting activities.

Slide 9

The explosion of hydrogen gas is a popular teacher demonstration. This can be done either by combining a 2:1 mixture of hydrogen to oxygen in a balloon or bubbling this mixture through soapy water as shown in this video. The 2:1 ratio provides the stoichiometric amounts of hydrogen to oxygen required in the balanced chemical equation for this reaction:

$2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O(g)$

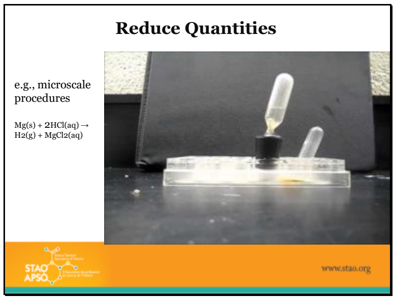
Consequently, this gas mixture releases the maximum amount of energy possible for this reaction. The sound of the explosion can be deafening, especially for those closest to it, like the teacher. That's why the presenters in the video wore ear protection.

Other appropriate precautions to minimize risk include:
partially fill balloons with gas; use fewer soap bubbles;
open doors and windows to reduce possible damage resulting from reverberations;
have students move a safe distance of at least 5 m from the demonstration bench;
warn students to cover their ears prior to the explosion and double check that they have.

The risk of injury can be greatly reduced by conducting this demo on a smaller scale, as you'll see in the next slide.

Source: https://www.youtube.com/watch?v=U-RBtbs_Ktg

Slide 10



The collection of gases by downward displacement of water is a common chemistry related activity. In this case, the activities are conducted on the microscale level by using well plates rather than test tubes and beakers. In this example, hydrogen gas is collected by the reaction of magnesium in HCl in one well plate. Oxygen is generated by the decomposition of 6% hydrogen peroxide using yeast or an Fe 3+ compound as catalyst. Both gases are collected in the same pipette bulb. The mixture can then be blown into a flame to produce a resounding but not deafening hydrogen pop.
The setup requires a one-holed stopper fitted with the slim portion of the pipette bulb.
As with all microscale activities, the waste generated in this example is minimal. Because small quantities are used, students can do this activity several times to achieve the desired results at minimal chemical cost.
Source:
https://www.youtube.com/watch?v=OZ2Atg2sTWI&t=3s

Slide 11

This demonstration shows a typical demonstration of the reaction of sodium metal in water to produce flammable hydrogen gas and water. The flame is the result of the combustion of hydrogen.
Group discussion: Small groups (5 min)
Ask participants to share some of their experiences with this demo and mishaps that they have heard of. Some include: hot sodium shattering the beaker (this is a more significant problem with potassium, projectiles of sodium being launched out of the container and onto observers).

Continue the discussion by asking participants to identify the hazards (e.g., heat, flames, broken glass, projectiles) and ask them for controls or precautions that could be put in place to minimize risk.

Controls (or precautions) include:

- use a smaller piece
- check the beaker for cracks
- wear PPE
- surround the demo with a blast shield
- place a wire square over the mouth of the test tube to prevent sodium projectiles from leaving the beaker but allowing hydrogen gas to diffuse outward

Source: https://www.youtube.com/watch?v=ODf_sPexS2Q

Slide 12

This demonstration illustrates a much safer way to demonstrate the reaction of sodium metal with water. A small piece of sodium is added to a mixture of mineral oil and water. The water layer contains a phenolphthalein indicator which turns pink because of the reaction between the sodium and water. The advantage of conducting the demonstration this way over the previous example is that the reaction occurs slowly so students can see the formation of hydrogen bubbles. Consequently, there is no chance of projectiles of sodium metal launching out of the container.
Source: http://www.youtube.com/watch?v=CObTHDG2z_I

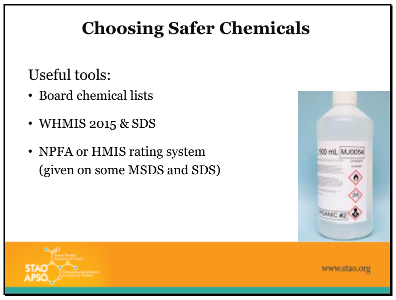
Slide 13

Elephant toothpaste is a popular demonstration involving the decomposition of hydrogen peroxide in the presence of a catalyst. Dish soap is normally added to the demonstration to generate foam and make the demo more spectacular. The product that you see in the video is foamy water. 30% hydrogen peroxide is sometimes used to conduct this demonstration. This product is very corrosive so appropriate personal protection must be worn. As you'll see in this video, using a large quantity of hydrogen peroxide generated a great deal of waste to clean up.
Source: https://www.youtube.com/watch?v=7qtX6XgDeDY

Slide 14

In this video, the demonstrator uses 6% hydrogen peroxide to conduct the elephant toothpaste demonstration. The catalyst, in this case, is the slurry of yeast and water. The advantage of this catalyst over chemical catalysts is that there are no disposal concerns. This demonstration may not be as spectacular as the one with 30% but the risk of injury from skin coming in contact with hydrogen peroxide is greatly reduced because a lower concentration is used.
Source:
https://www.youtube.com/watch?v=4N0m95PExHY&feature=related

Slide 15

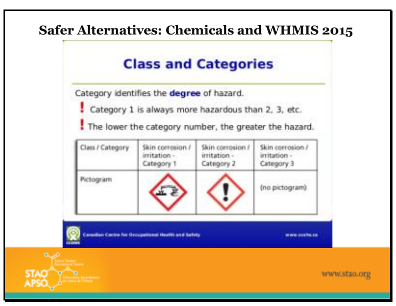


This slide summarizes some of the important information sources to consult when selecting chemicals appropriate for an activity. Many boards have published lists of banned chemicals. Others have produced lists of approved chemicals. Regardless of which format is used, it's imperative that teachers consult their board chemical protocols when selecting chemicals.

After the board list, teachers should consult the safety data sheet for the chemical under consideration. In addition to hazard and storage information, the SDS has important information on precautions required, first aid information, and strategies for dealing with spills. The bottle of methanol in this photo shows the pictograms typically found on a WHMIS 2015 label.

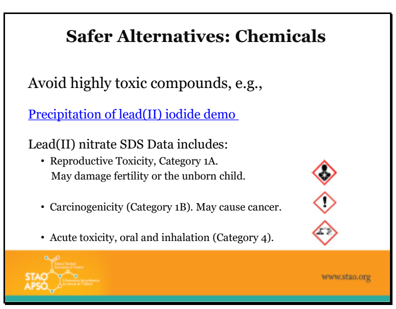
The National Fire Protection Association (NFPA) and Hazardous Materials Information System (HMIS) are two common chemical hazard classification systems that are no longer supported in WHMIS 2015. However, the typical high school chemical storage may have several bottles whose labels have these classification systems.

Slide 16



WHMIS 2015 groups hazardous chemicals into classes in categories. For example, skin corrosion/irritation is a WHMIS 2015 class. Each class of chemicals can also be subdivided into one or more categories where the number of the category signifies the degree of the hazard – the lower the category number, the greater the hazard. Category 2 is less hazardous and so on. Some categories may also have letters. Therefore, 1A is more hazardous than 1B.

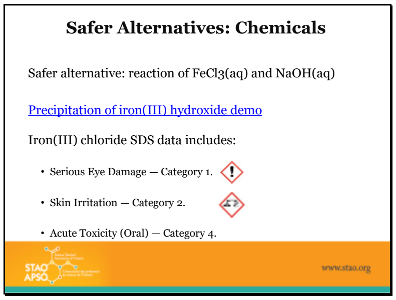
Slide 17



Choosing less toxic chemicals is a good example of a safer alternative strategy. For example, the reaction of lead(II) nitrate with potassium iodide solutions to produce a bright yellow lead(II) iodide precipitate is a popular way of illustrating precipitate formation or double displacement reactions. However, lead(II) nitrate is quite toxic as you can see from the SDS hazard classes and categories in this slide. Furthermore, use of toxic substances like lead(II) nitrate greatly increases the disposal costs – a consideration that the classroom teacher often doesn't consider because disposal costs are usually borne by the school board.

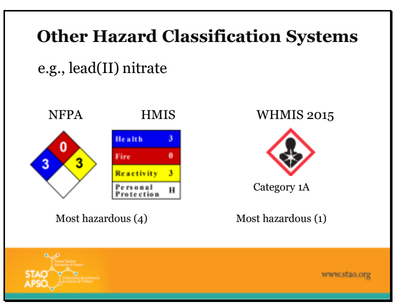
Given the disposal costs and health risks, why not use a safer alternative – as you will see on the next slide.
Source of lead(II) iodide precipitate:
https://www.youtube.com/watch?v=M0sKFmcOPZk

Slide 18



In this video, sodium hydroxide solution is first added to an iron three chloride solution to produce an iron hydroxide precipitate. Then, a dilute HCl solution is added which "undissolves" the precipitate. Then, more sodium hydroxide solution is added to make the precipitate form again. This sequence is useful to deal with a common misconception about chemical reactions – that chemical reactions are irreversible. In fact, there is an entire unit in the grade 12 chemistry course on reversible chemical reactions.
Once the mixture in the flask returns to its initial red dissolved condition, it can be stoppered and reused several times in other classes. This reduces both the cost of replacement chemicals and disposal.
Source of iron(III) hydroxide precipitate:
https://www.youtube.com/watch?v=asdDyWmE9KQ&t=1s

Slide 19



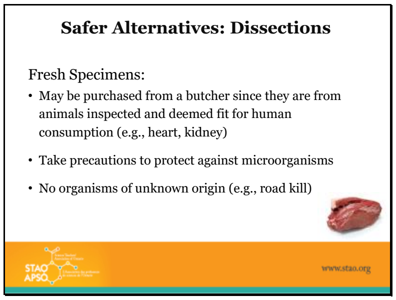
The National Fire Protection Association (NFPA) and Hazardous Materials Information System (HMIS) are two common chemical hazard classification systems that are no longer supported in WHMIS 2015. However, the typical high school chemical storage may have several bottles whose labels have these classification systems.

In both NFPA and HMIS, the severity of the hazard ranges from 0 to 4 with 4 being the most hazardous. In WHMIS 2015, category 1 is most hazardous. Category 2 is less hazardous and so on. Some categories may have letters. Therefore, 1A is more hazardous than 1B.

Slide 20

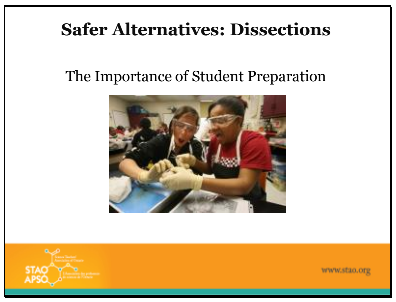
The general rule of thumb for obtaining safe organisms is to purchase them from an approved source. For example, preserved specimens for dissection should be purchased from board approved vendors. This helps to ensure that the specimens were prepared and preserved in a safe manner.

Slide 21



Fresh organs, e.g., eyes, hearts, and kidneys, may be purchased from a butcher or abattoir since the animals they came from were inspected and deemed fit for human consumption. Organisms of unknown origin, e.g., road kill, should not be brought to school.

Slide 22



In addition to well-prepared specimens and well-maintained tools, student training is critical when planning dissection activity. Students must not only have the technical skills necessary to conduct the activity and a clear understanding of what they must do, they must also overcome any emotional or maturity baggage that they may have regarding the activity.

Small group discussion: What student preparation strategies have you found to be effective when preparing for a dissection?

Slide 23

Culturing microorganisms is a common activity in some senior biology classes. STAO does not recommend culturing microorganisms collected from environmental services like phones, doorknobs, etc. because you have no idea what microorganisms have been collected. Prepared samples of safe microorganisms are inexpensive and can be purchased from common science equipment suppliers. STAO recommends that only risk group 1 organisms be used for this purpose.

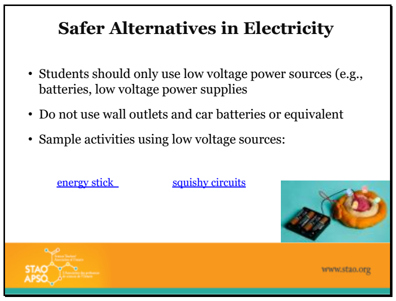
Slide 24

The slide provides interesting data about cultures grown from swabbing computer keyboards.

Slide 25

The slide provides best practices to be followed when culturing microorganisms.

Slide 26

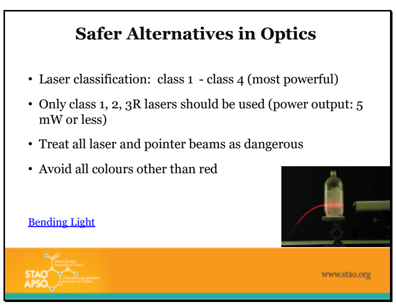


Low-voltage power sources should always be used for electricity experiments. Students should never work with power supply directly from a 110v wall outlet. The energy stick and squishy circuits videos provide fun examples of the use of low-voltage power sources in activities.

Slide 27

When handling or storing 9v batteries, be careful not to allow metal objects to come in contact with the terminals of the battery. This can short the battery and can generate considerable heat, as you will see in the video.

Slide 28



Red lasers that are properly labelled in the 3-5 mW range have not caused eye damage according to this Scientific American article.

However, since laser pointers are readily available from a variety of sources, the quality and power output of these devices may be suspect. That's why it's important to treat all lasers and pointing devices as potentially dangerous. Hence, never point one at another person or onto a reflective surface.

The remaining text is from the Scientific American reference:
"Why even worry about 5 mW (5 thousandths of a watt), which is less than one percent of one percent of the power of a 60-Watt incandescent bulb? First, the numbers are

used differently. Light bulb wattage measures the power it uses. It only converts about 10 percent of that electrical power into light. In a laser, the power is a measure of the light output.

Second, the light bulb gives light in all directions so you only see a small part of the whole. As you move away from the bulb, you see a quarter of the light every time the distance is doubled. A laser gives light in one small beam. If it gets into the eye, you receive all the laser's energy, not just a fraction.
Third, a light bulb gives off light at many different wavelengths (different photon energies). A laser is a pure tone, only one wavelength. The coherent light will be more damaging."

Slide 29

Conclusion

Review the key themes of the presentation and invite participants to outline their next steps in incorporating safer alternatives in their practice.