American Chemical Society

ACS Chemistry for Life®

Analyzing Hazards and Risks in High School Chemistry Labs

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ACS – Partnering with Teachers for Safety Education

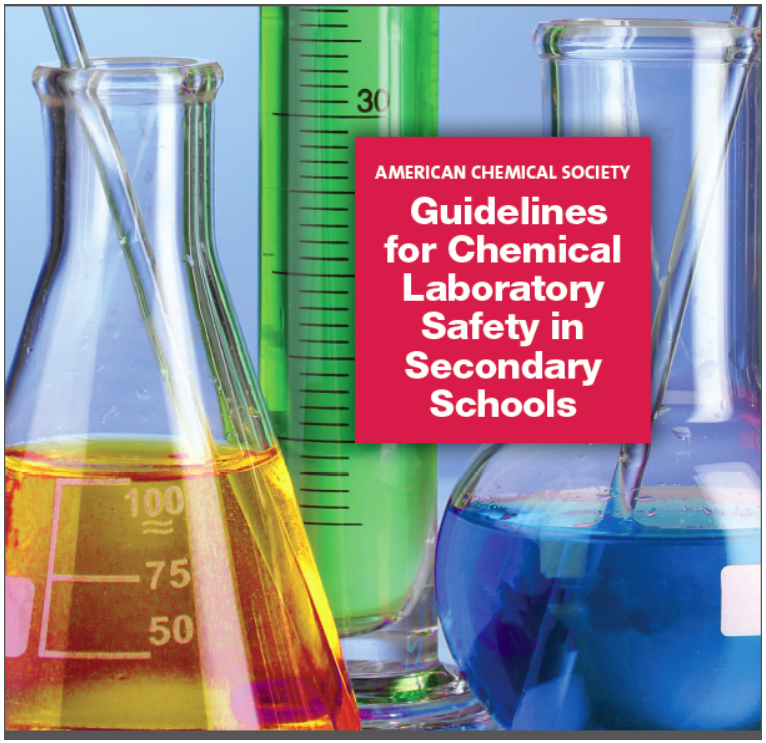
- A number of highly publicized accidents in school chemistry labs resulted in serious injuries to students.
- After three accidents over an eight-week period in 2014, the Chemical Safety Board (CSB) issued a safety bulletin highlighting key lessons for preventing future incidents.
- ACS worked closely with the CSB and other organizations, issuing safety alerts and trying to understand what support is needed to prevent such accidents.

ACS Guidelines and Recommendations for Teaching High School Chemistry

- 1,028 teachers contributed to a survey the ACS conducted in preparation for its 2017 revisions to the Guidelines.
- **98% of teachers stated that safety in the chemistry classroom/laboratory is important!**
- In conversations, one educator summed up the problem this way: *"Yes, I know teaching chemical safety is important, but how do I know what and how to teach it?"*

Safety Education Guidelines

Download at www.acs.org/safety

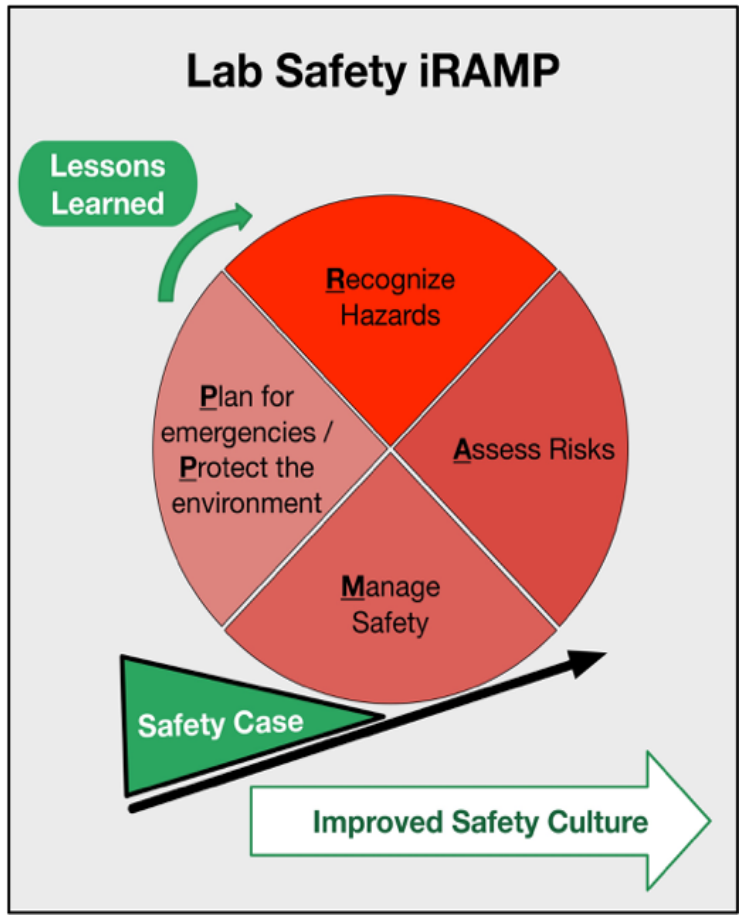


Safety Education Guidelines

- Emphasize the importance of integrating safety education throughout students' entire chemistry education.
- Provide guidance on expected students' knowledge, skills, attitudes, and competencies in the area of chemical safety.
- Source of safety reference information for teachers.
- Organized around the concept of **RAMP** – an acronym for the Four Principles of Safety:

  Recognize the hazard,
  Assess the risk of the hazard,
  Minimize the risk of the hazard, and
  Prepare for Emergencies.

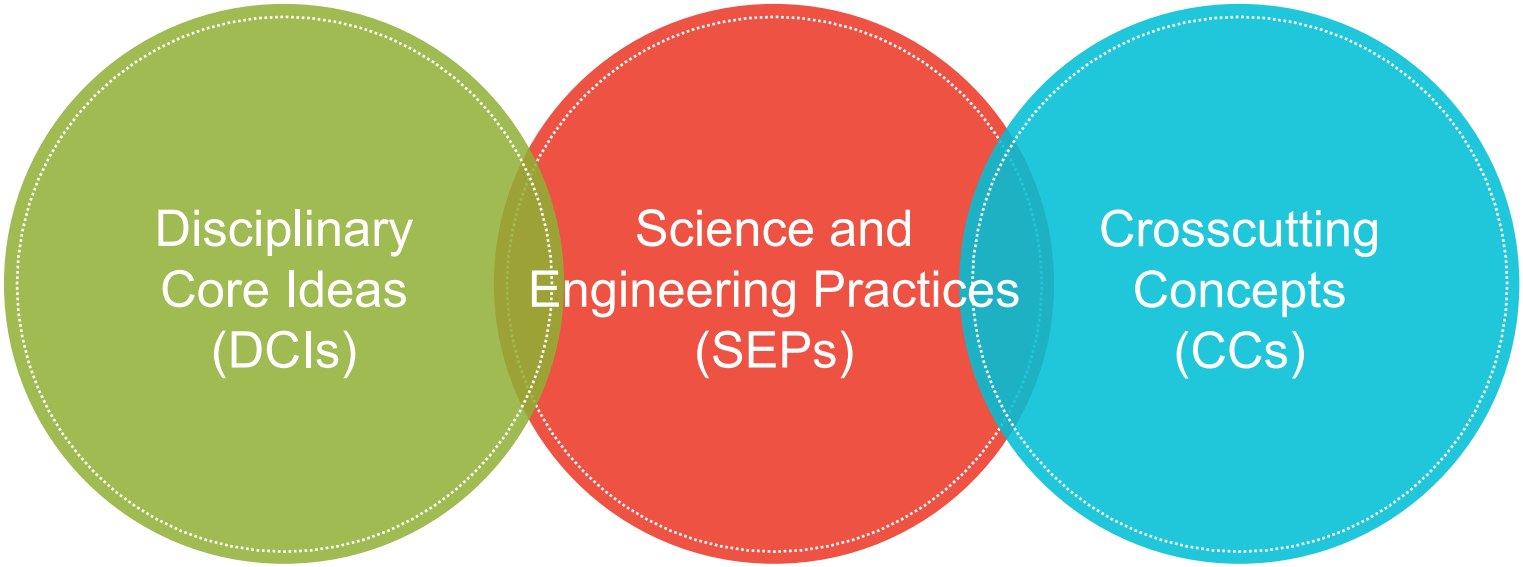
Moving from Rules to Reasoning



Next Generation Science Standards conceptual shifts

Reflect interconnected nature of science as it is practiced and experienced

THREE DIMENSIONS



Science & Engineering Practices (from NGSS)

- Asking Questions and Defining Problems.
- Planning and Carrying Out Investigations.
- Analyzing and Interpreting Data.
- Developing and Using Models.
- Constructing Explanations and Designing Solutions.
- Engaging in Argument from Evidence.
- Using Mathematics and Computational Thinking.
- Obtaining, Evaluating, and Communicating Information.

Problem-Solving Skills and RAMP

Students should be able to apply the scientific method to:

- Define a problem clearly.
- Develop testable hypothesis.
- Analyze data using appropriate statistical methods.
- Draw appropriate conclusions.

Student should be able to design a safe laboratory operation by:

- Recognizing Hazards.
- Assessing Risks.
- Minimizing Risks.
- Preparing for Emergencies.

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Analyzing Hazards and Risks in High School Chemistry Labs Workshop

Reno (NV)
Charlotte(NC)
National Harbor (MD)

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Goals and Objectives

- Improve safety by increasing awareness.
- Review RAMP process for planning safe science activities.

  Recognize hazards

  Assess risks

  Minimize risks

  Prepare for emergencies

- Carry out RAMP analysis for 2-3 common labs.
- Highlight ACS resources for chemical safety.
- Encourage future outreach!

Moving Beyond Rules – RAMP It Up for Safety!

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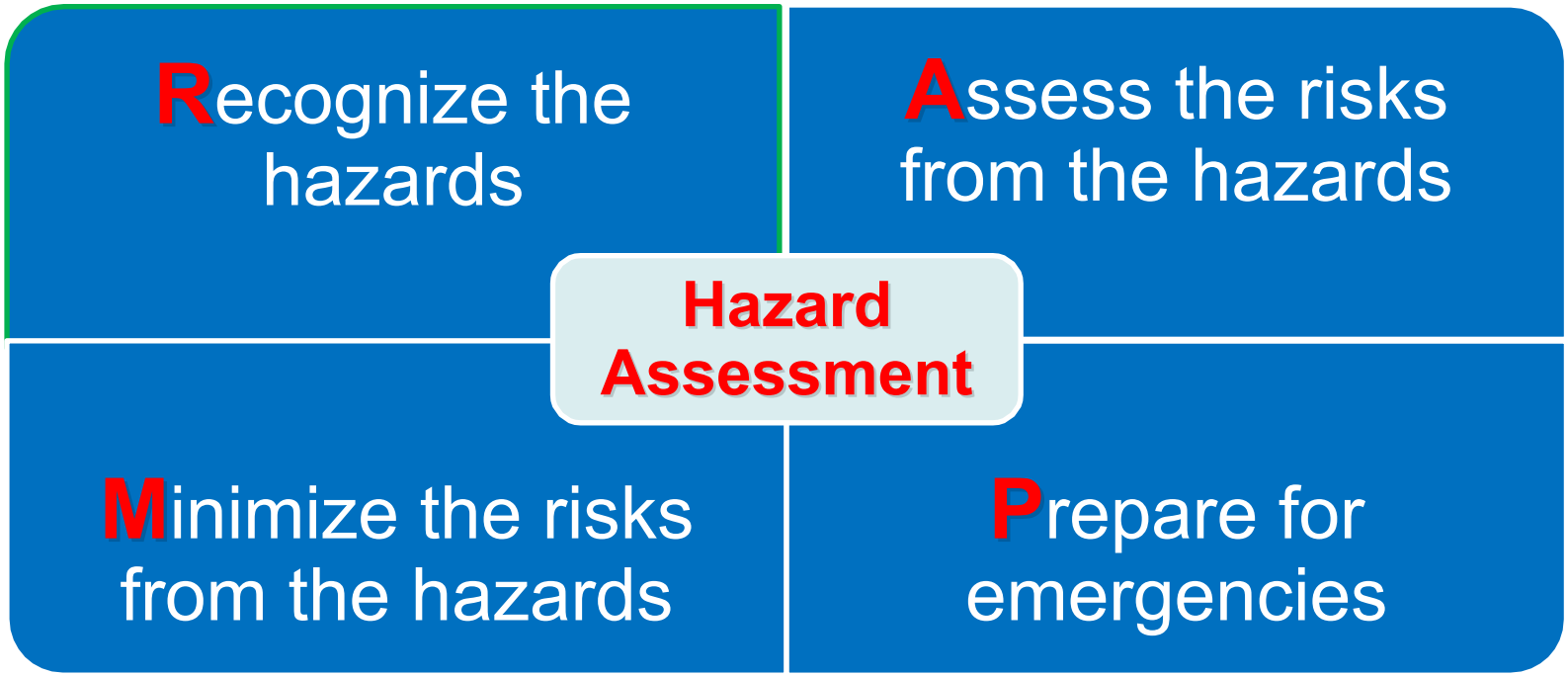


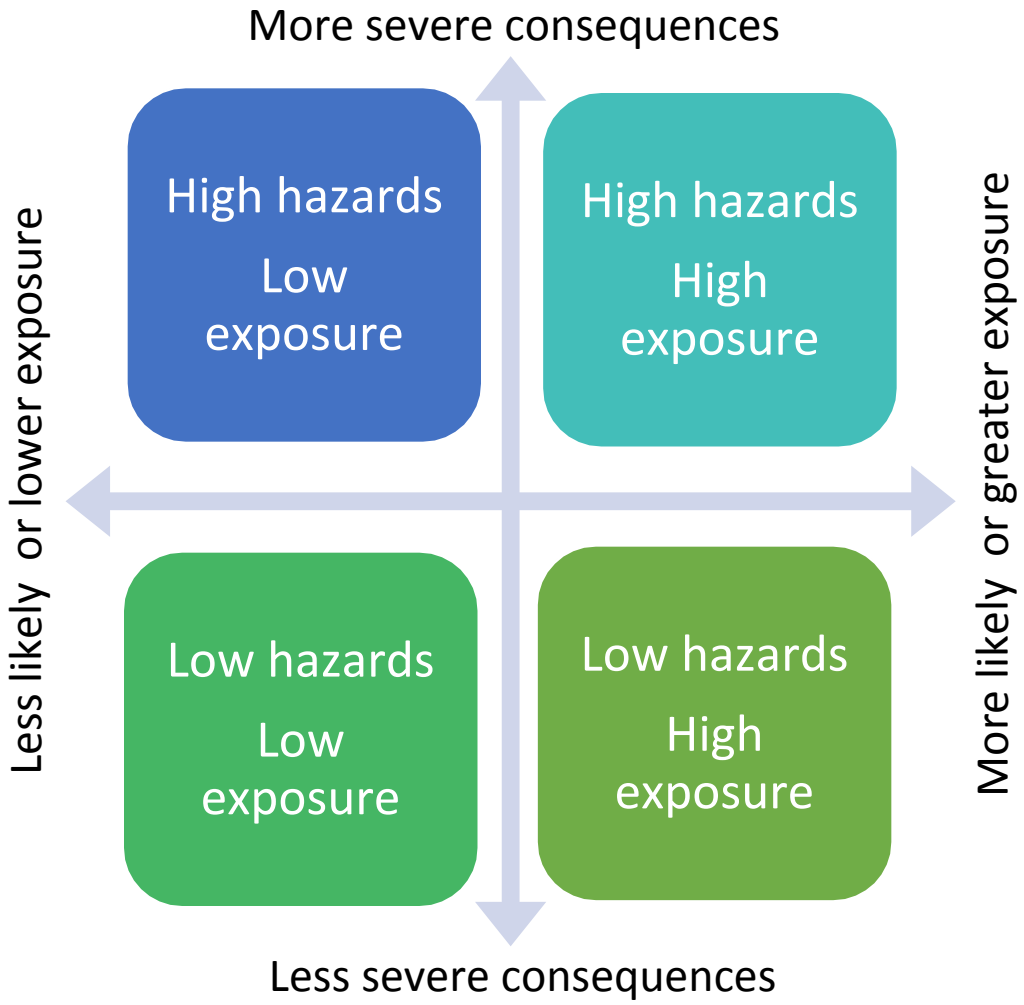
Developed by Robert E. Hill and David F. Finster in their textbook, *Laboratory Safety for Chemistry Students*

Recognize the Hazards

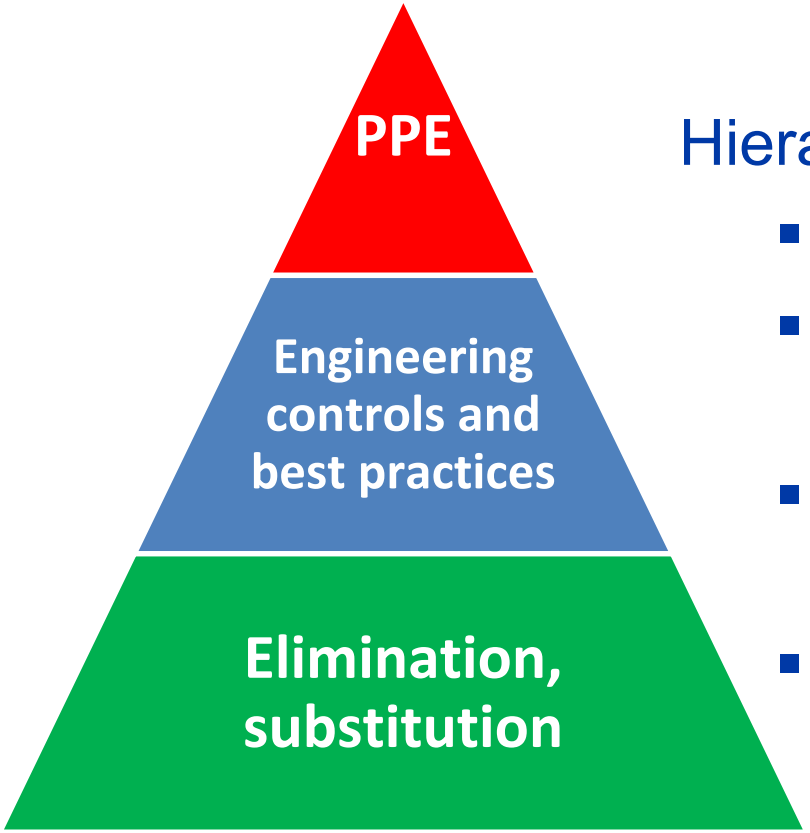
- Chemical, physical, health and environmental
- Equipment, conditions, procedures and setting

Assess the Risks – Risk Matrix

- Perform hazard and risk assessment prior to performing any hands-on lab activity.
- Analyze likelihood and severity of potential risks.
  - What level of danger is posed by the hazards?
  - **Low/medium/high**



Minimize the Risks



Hierarchy of controls – "Safety Pyramid"

- Elimination, substitution
- Engineering (ventilation, hoods, storage cabinets)
- Prudent practices (standard procedures, safety precautions)
- Personal protective equipment

Eliminate hazards, change procedure or modify process, use special safety equipment, wear appropriate PPE.

Prepare for Emergencies

- What “emergencies” can occur?
  - Anticipate accidents.
- Is necessary response equipment present?
  - Inspect and maintain on a regular basis.
- Review and practice procedures for handling common emergencies.

RAMP Analysis of Chemistry Experiments

Combustion of Mg – Empirical Formula of Magnesium Oxide

Mole Ratio – Reaction of $AgNO_3$ and Copper

Periodic Trends – Reactivity of Halogens

Combustion of Mg – Empirical Formula of Magnesium Oxide

Materials: Mg “ribbon”

Equipment and Procedure: Heat coiled, pre-weighed Mg ribbon in crucible over Bunsen burner flame. Lift crucible lid periodically. Cool crucible and weigh product.

Calculate percent composition of product. Determine empirical formula of magnesium oxide.

Mole Ratio – Reaction of $AgNO_3$ with Copper

Materials: $AgNO_3$(s), Cu(m); 3 M HNO_3, H_2O and acetone.

Procedure: Dissolve precise mass $AgNO_3$ in water. Suspend pre-weighed Cu in soln and add 3 drops HNO_3. Rinse Ag crystals from wire with water, decant liquid, and dry solid before weighing. Wash, dry, and mass Cu wire.

Compare mass and moles of Ag produced versus mass and moles of Cu reacted. Determine mole ratio.

Reactivity of Halogens

Materials: ***dilute*** (0.05 M) solutions of Cl_2, Br_2 and I_2 "water;" aqueous 0.1 M NaCl, NaBr and NaI; hydrocarbon solvent – cyclohexane, hexane or mineral oil.

Procedure: *Prepare two test tubes with each halogen* – 10 drops of halogen "water" and 20 drops of solvent. Observe separation and color of layers. To test tubes containing Cl_2, add 10 drops of NaBr or NaI. To test tubes containing Br_2, NaCl or NaI. To test tubes containing I_2, add NaCl or NaBr.

Observe color changes. Does halogen X_2 react with NaY?

R A M P Up Your Lab Activities and Demonstrations Template

Before performing any demonstration or having students complete laboratory activities, use this template to RAMP up safety.
RECOGNIZE potential hazards, review the chemicals, equipment, and procedures used. (Common hazards are shown on the back of this page.)
ASSESS and MINIMIZE the risks from those hazards and PREPARE for emergencies.

RECOGNIZE the hazards	ASSESS the risks of hazards	MINIMIZE the risks of hazards	PREPARE for emergencies from uncontrolled hazards
Identify Globally Harmonized System (GHS) hazards* present in activity, including reactants and products. Identify the process (temperature, pressure, electrical) hazards.	Think about how you might be exposed to the hazard and the results of exposure. Identify the most important risks that you will manage.	Evaluate all chemicals, equipment, and procedures and identify ways to minimize risks that are present. Layer controls if needed to improve protection (e.g. goggles and shield)	Know how to respond to chemical exposure, spills, cuts, fires, burns, and other possible incidents. Test emergency equipment. Practice emergency protocols.

*A list of GHS Hazard Statements may be found at: http://bit.ly/GHS-Hazards

Common Hazards in Lab Activities and Demonstrations

RECOGNIZE hazards. http://bit.ly/GHS-Hazards	**ASSESS** the risks of hazards.	**MINIMIZE** the risks from hazards.	**PREPARE** for emergencies from uncontrolled hazards.
• Broken glassware	• Cuts and scratches on the skin • Glass sharps in the eye	• Handle broken glassware with gloves. • Do not allow students to clean up broken glassware. • Always wear safety goggles when handling chemicals in the lab. • Do not soak dishes in cloudy sink water where broken glassware is not visible.	• Broken glassware box in the laboratory. • Small broom and dustpan. • Wear protective eyeware.
• Fire	• Burns to people and equipment • Ignition of volatile liquid vapors • Smoke inhalation	• Do not open flammable liquid bottles in the presence of a flame or hot surface. • Always use caution around open flames. Tie back long hair, secure loose clothing, and never reach over an open flame. • Keep flames away from flammable substances. • Exercise caution when using a heat source. Hot plates should be turned off and unplugged as soon as they are no longer needed. • Remove excess solvents from work area	• Dry chemical (ABC-type) fire extinguisher. • Fire blanket on wall. • Know location of gas master control valve. • Lab safety shield for demonstrations • Review Safety Data Sheets and pay particular attention to Section 5 for firefighting measures and special extinguishing materials
• Acid or base	• Irritation/corrosion of skin and eyes • Respiratory distress	• When working with acids and bases, if any solution gets on your skin immediately rinse the area with water. • When diluting acids, always add acid to water. • Use minimum concentration necessary.	• Eyewash station • Shower or body drench hose • Review Safety Data Sheets. • Ventilation fan • Baking soda/Citric acid to neutralize spills – do not use on skin.
• Spills	• Possible irritation of skin and eyes • Respirat • Flamma	• Neutralize acids with sodium bicarbonate.	• Ventilation fan sand and vermiculite or cat litter iew Safety Data Sheets

RAMP Discussion

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Sharing Insights

And

Lessons Learned

How do the safety strategies presented in this session fit with your current practices?

- *This is exactly what I needed!*
- *Can be used with each lab session.*
- *Clarified the need for a written safety assessment vs. just a mental one.*
- *This will help me think through safety procedures.*
- *RAMP strategy is very relevant.*
- *Definitely will have my students working on RAMP.*
- *Good points that teachers are not taught.*
- *Restated info that I already knew but in a formatted structure.*
- *It gives a consistent format to think about safety w/o a bunch of rules.*

What did you learn during today's session that you anticipate incorporating into your teaching?

- *I liked an approach of being proactive in safety. I also like an idea of having students think about the "whys" behind safety rules.*
- *Risk assessment.*
- *Written safety assessment .*
- *I actually learned how to do RAMP this time.*
- *Preventive practices.*
- *Risks vs Hazards.*
- *During the PD w/chem teachers presenting the RAMP worksheet as a potential classroom tool for students.*
- *Using RAMP analysis with students.*

What did you learn during today's session that you anticipate incorporating into your teaching?

- *Writing down safety myself – not just safety my students put in lab report.*
- *Being more intentional about incorporating safety into lab prep.*
- *Reading SDS sheets before using the chemicals in a demo or experiment. Using the RAMP sheet to assess safety of each experiment with my colleagues.*
- *It raised my awareness in a organized way to think about safety in the lab.*
- *Risks vs hazards – thinking about how to minimize risks of intrinsically hazardous stuff.*

Possible barriers?

- *Time.*
- *May seem overwhelming for new teachers.*
- *Time! Would help to have some workout RAMP examples.*
- *Lack of resources provided by school.*
- *Cluttered classrooms.*
- *Inheriting unsafe/confusing lab and lab equipment.*
- *Lack of funding for upgrading my storage and disposal.*
- *My knowledge and I am working on it!*
- *Lab space.*
- *Teacher's know-it-all mentality.*

Possible barriers?

- *Where to find information about hazards.*
- *Cost/safety equipment availability.*
- *Routine.*
- *Different types of students in the classroom.*
- *Mostly cultural – building this expectation of safety.*

Was there anything NOT helpful in this session?

- *Need more time to practice. It would be great if you bring specific lab items and we could practice safe practices.*
- *Less time for background more for actual "doing" and discussion.*
- *Would like more visual examples of accidents and procedures not followed.*
- *Less PowerPoint lecture.*