Assessing RAMP-based Risk Assessment Instruction in an Undergraduate Organic Chemistry Lab

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Background

The lack of chemical safety education in undergraduate chemistry curriculum has been widely recognized. All undergraduates, at the minimum, are expected to be able to **recognize hazards** in the lab, **assess the risks** associated with these hazards, develop strategies **to minimize those risks** and **prepare/plan for emergencies (RAMP)**. More research is needed to investigate how incorporating risk assessment instructions improve students' risk assessment skills. People get hurt when they don't have the necessary knowledge and skill to work safely in the lab. Engaging students in the risk assessment of safety hazards associated with lab experiences builds safety competence and strong safety ethic.

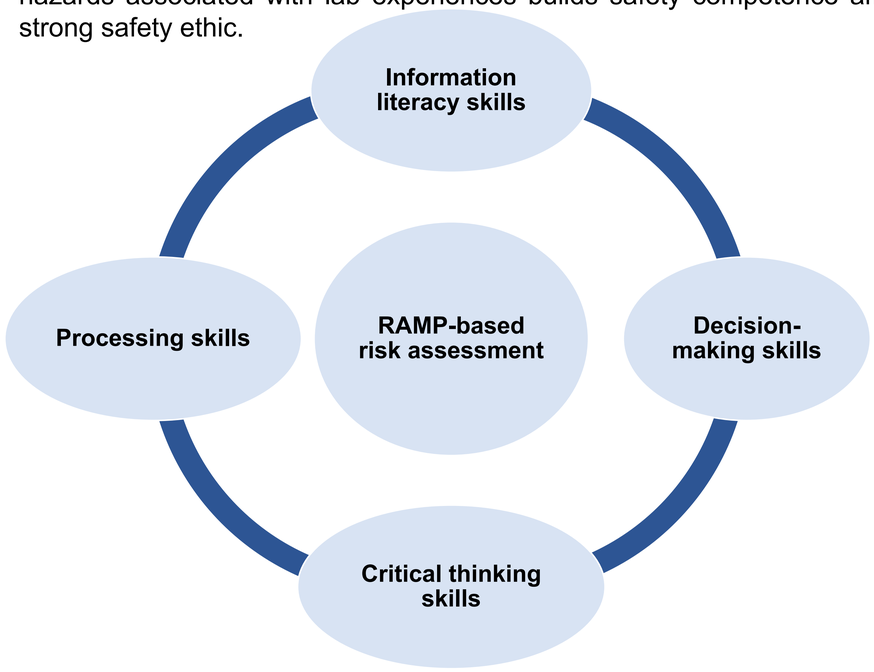
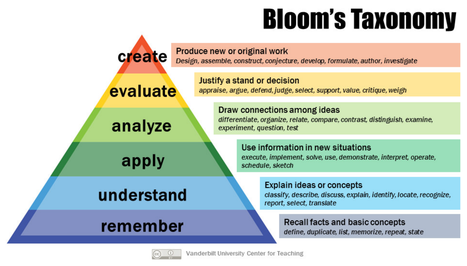


Figure 1: Skills required for performing RAMP-based risk assessment

Theoretical framework



References

1) Hill Jr, R. H. (2016). Undergraduates need a safety education!. Journal of Chemical Education, 93(9), 1495-1498.;
2) Hill Jr, R. H., & Finster, D. C. (2016). Laboratory safety for chemistry students. John Wiley & Sons.; **3)** Stayanchi, J. (2017). Higher order thinking through Bloom's taxonomy. *Kwansei Gakuin University Humanities Review*, *22*, 117-124.; **4)** Stuart, R. B., & McEwen, L. R. (2016). The safety "use case": co-developing chemical information management and laboratory safety skills. *Journal of Chemical Education*, *93*(3), 516-526.

Research Questions

RQ1: What are the prior experiences of students taking Organic Chemistry Lab I?
RQ2: Does incorporating explicit instruction on risk assessment into the undergraduate organic chemistry lab I using the RAMP framework improve students' risk assessment skills?

Study Design

- **Control (traditional)** — No prelab risk assessment quiz
- **Experimental Group I (revised)** — Open-ended prelab risk assessment quiz for each experiment
- **Experimental Group II (revised)** — Fill-in-multiple blanks prelab risk assessment quiz for each experiment

Sample risk assessment quiz

Question 1 — 2 pts

STEP 1: Crush and grind a whole nutmeg with a mortar and pestle for approximately 5 min. (no need to pulverize). Weigh the ground nutmeg and transfer it to a 50 mL round-bottomed flask.

These controls are definitely required:

- Wear a lab coat, nitrile gloves, and safety goggles
- Have a first aid kit on location

Hazard:
Likelihood:
Severity:
Control:

Data Collection and Analysis

- **Prior lab experience Survey responses**
- **Pre-Post risk assessment tests scores (ANOVA and ANCOVA)**
- Individual reflection responses for weekly assignments (Quality of reflection graded by chemical safety experts)

Acknowledgement

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Preliminary Findings

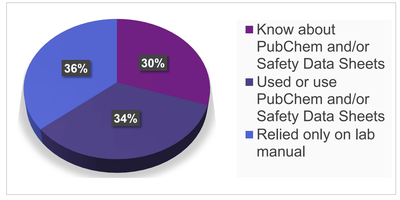
Students' Prior experiences

Q1. Reflecting upon your experiences in other lab, how did you normally go about preparing for a lab with respect to the potential safety risks associated with the procedures?

- "In past labs, I would read any provided information and listen to the lab instructors feed back, otherwise I didn't prepare"
- "Teacher would tell us the potential safety risks for the lab"
- "I would always review safety documents for each lab and research additional material (like SDS sheets) when necessary"

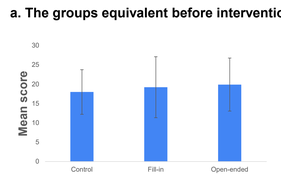
Majority **relied on their lab manual** and **instructor's feedback**

Q2. Select the best option(s) that describes your experience with these chemical information outlets



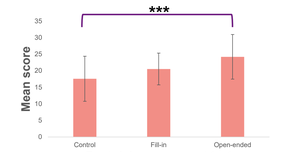
Students' ability to perform risk assessment

a. The groups equivalent before intervention?



p<0.05 level (**p=0.502**)

b. There is a significant group effect after intervention



after controlling for pretest score at p<0.05 level (**p<0.001**). Cohen's d = **1.070**

Students' application of RAMP and thinking skills

I believe step 2 has the highest risk associated with it because it has the highest risk rating of 10. I believe that step 2 has the highest risk because it has the potential to start a fire. If a direct flame or static energy is applied right next to diethyl ether there is an extremely high chance a fire will be started. Also, if the fire is not treated properly with a fire extinguisher or a non-direct stream of water the fire will continue to grow and most likely cause multiple medical injuries including but not limited to burns. As well as causing significant structural damage.

- Recognize hazards
- Assess risks
- Minimize risks

Step 2 is the highest RR value with a value of 20. This is the highest because often in the lab there is an urge to keep moving quickly in the lab which can result in the skipping of safety precautions, like wearing hot gloves when touching heated glassware. This can cause a serious burn on someone's hand which could result in dropping the glassware which would compound the injury. This can be minimized by using hot gloves whenever glassware could be heated to an uncomfortable temperature.

- Recognize hazards
- Assess risks
- Minimize risks

Preliminary Conclusion

- **Control** — Not getting enough support (lack of higher order thinking)
- **Fill-in-multiple blanks** — Not pushing them (reduced processing)
- **Open-ended** — Providing enough support (promotes higher order thinking skills)