



Safety Education – Not the same as Safety Training

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What Happens When Science Majors are not Educated in Safety

- ▶ Recent graduates suffer injuries to themselves and others
 - ▶ In past 20 years – 164 children and educators injured in demonstrations using flammable solvents¹; Result of inadequate safety education (understanding)
 - ▶ Reported laboratory incidents – 2.5 incidents/week in academic setting²
 - ▶ CDC reported Educational Services industry – 2nd highest among top industries in injuries from chemical events; 2/3's injuries among students³

▶ ¹SB Sigmann, Playing with Fire: Chemical Safety Expertise Required, J Chem Ed, 2018, 95(10), 1736-1746; ²R Stuart, R Toreki, Learning Opportunities in Three Years of Hazmat Headlines, J Chem Health Saf, 2014, 21(2), 2; ³AR Anderson, J Wu, Top Five Industries Resulting in Injuries from Acute Chemical Incidents, Morbid Mortal Wkly Rep, 2015, 64 (2, April 10), 47-53.



What Happens When Science Majors are not Educated in Safety

- 32 incidents of solvent fires in demos caused 164 injuries – NOT included unreported, near misses (*S. Sigmann, JCE, 95 (10), 1736-46, 2018*)
- Educational system failing? (Systemic failure)
- Problem continues because teachers:
 - Have limited science education, chemical safety education
 - Lack training (*safety education*) in safely presenting science to children
 - Don't have appropriate safety equipment or proper venue
 - Pressured by public perception of chemistry; "Wow" factor (blowup stuff)
 - Compete with Media, TV, Movies, Internet videos



What Happens When Science Majors are not Educated in Safety – *Why?*

- *1st Why:* Knew solvents flammable but did not understand flammable properties of solvents; and/or Did not have safety ethic and did not think about safety
- *2nd Why:* Did not learn to think critically about safety - Not educated in flammable (other hazardous) chemical properties and behaviors
- *3rd Why:* Did not receive a safety education that would teach knowledge of hazards, critical thinking about safety, assessing and minimizing risks, and would develop safety ethic
- *4th Why:* Safety education is missing from chemistry curriculum – A GAP in the professional chemists' education
- *5th Why:* Unknown but Safety training has been substituted for safety education in most institutions and deemed adequate safety instruction



“THE GAP” in Chemists’ Professional Education – No Safety Education!

- Underlying cause for many incidents (Not acknowledged/recognized by academic institutions far removed from events)
- Chemists studying at our universities and colleges:
 - NOT taught how to: Recognize (understand) hazards; Assess risks of hazards; Minimize the risks of hazards; Prepare for emergencies
 - NOT prepared to think critically about safety when they go to their new jobs (researchers, bench chemists, teachers,...)
- New Graduates and Chemists DO NOT have safety knowledge to problem solve in safety and do not have strong safety ethics
- Safety Education is missing; “The Gap” in chemists education



“THE GAP” in Chemists’ Professional Education – No Safety Education!

- Consider that you might get a bad grade or be embarrassed or ridiculed, if you can’t explain or don’t understand:
 - Writing balanced equations; Quantum Theory, Diels-Alder Reactions, Molecular Orbital Levels, Stereochemistry of Organic Rings, Metal ion behaviors
- But you or others can be injured, maimed, or die, if you are not educated in safety, don’t think critically about safety, and don’t understand how to:
 - Recognize and understand hazards; Assess risks of hazards; Minimize risks of hazards; Prepare for emergencies



“Why” is Safety Education Missing

- Bravado – I survived without knowing or worrying about safety and you can too (*Real Chemists don't need safety!*); Never educated in safety so don't care much about safety education
- Think teaching safety presents a “negative” view of chemistry; only “positive” view should be taught
- Far removed from consequences of missing safety education (NOT held accountable for not teaching safety)
- Safety training meets student's needs (and compliance), don't need for safety education
- Somebody else's job to teach safety; No room in the curriculum
- Don't know enough to teach safety



“THE GAP” in Chemists’ Professional Education – What They Need to Know!

- First & Foremost – Learn to **R**ecognize and understand hazards
 - Not enough to know “flammable”, “toxic”, “explosive”, “pyrophoric”, “allergenic”
 - Need to understand these terms, properties, and chemical behaviors
- Learn to **A**ssess risks of hazards
- Learn to **M**inimize risks of hazards by understanding methods, equipment, procedures
- Learn to **P**repare for emergencies
- **RAMP** (from *Hill & Finster, Laboratory Safety for Chemistry Students, 2nd Ed, 2016, John Wiley & Sons*)



What should you need to recognize and understand hazards - Flammables

► Flammables

- Why flammables important/needed
- Chemistry of fire/combustion; Reaction profiles; Release of energy; Chemical properties (terms) pertaining to flammability; Using gas laws to predict behavior in fires and Flame jetting; Chemical structure associations
- Hazard rating systems (GHS & NFPA)
- How fires start – Fire Triangle/Tetrahedron; Sources of ignition; Types of fires and fire extinguishers;



What is Safety Training and Why is it Important

- Important: Helps ensure safety/compliance for employers and employees
- Usually delivered by EHS Professionals in classrooms or on-line instruction
- Teaches rules, processes, and procedures specific to institution
 - Safety compliance, chemical hygiene plans, basic lab safety, special procedures for high hazard materials, chemical waste management, fire extinguisher use, compressed gas use, respirator training/fit testing, shipping hazardous materials, radiation safety compliance, etc.
- Covers topics necessary for compliance with laws and regulations
- Mechanism for employer to demonstrate compliance with local and federal safety laws



Safety Education versus Safety Training

Safety Education

- Audience: Students
- Purpose: Preparing students for independent thinking about safety in future
- Goals: Build knowledge continually over time, teach critical thinking
- Targets: Thought Processing
- Emphasizes: Principles, long-term learning

Safety Training

- Audience: Employees, Students
- Purpose: Preparing employees & students to follow rules/processes; Documents employer compliance
- Goals: Prepares learners to do specific things; Skill-building, Learn institution rules, practices
- Targets: Behaviors
- Emphasizes: Specific applications, short-term learning



Safety Education versus Safety Training

Safety Education

- Who teaches: Faculty(?), Staff
- Learning: Continuous, spiraling, in-depth; apply principles/concepts
- Testing: Tests based on knowledge and problem solving skills
- Focus: Teaching general knowledge & theory, understanding, critical thinking, problem solving, the “why”;

Safety Training

- Who trains: EHS, staff
- Learning: Step-by-step, what & how to do something; memorize
- Testing: Tests, if given, based on memorizing facts
- Focus: Institution specific; Rules, Compliance; Learning specific processes;

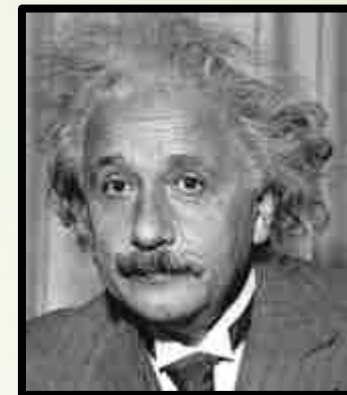


What Can EHS Do About “The Gap” – New Role: Promote Safety Education

- Consider why safety education is needed; how it differs from what you do
- Recognize safety training NOT adequate substitute for safety education
- Talk with faculty; Point out need for safety education in undergraduate curriculum – Not duplicated/replaced by safety training (both are necessary) [ACS Committee on Professional Development recommends]
- Offer assistance in developing safety education program
 - Using RAMP as basis for educational efforts; New ACS Exam available
- Recognize/Report institutions to ACS that include safety education in curriculum

Safety Education and Safety Training – Let's Close the “Gap”!

- Different but both important & needed
- Students need both but only get Safety Training
- Graduates missing critical thinking ability in safety; missing strong safety ethics (from safety education)
- “The Gap” in learning puts future chemistry graduates at increased, unrecognized risks.
- “The GAP” in “The Chemist’s Education” result - Chemists not being properly prepared to meet the world’s needs



***Concern for man and his fate must always form the chief interest of all technical endeavors. Never forget this in the midst of your diagrams and equations.”
Albert Einstein***