Green Chemistry and Toxicology: "Relevance" in the Chemistry Classroom

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Discussion Overview

- History of science education.
- Teaching to learn: What matters?
- What is social and environmental justice?
- Conclusion

A Brief History of Science…

- Science was born from positivism.
  - holds observation and measurement as the highest authority of valid knowledge
  - and as a foundational tool for scientific investigation.
- This empirical approach often leads to the idea that science is always better than or more valid than other disciplines.

One Discipline to Rule Them All

- Cobern (1994) wrote:
  - Even when interdisciplinary science curricula are adopted, they often continue to serve the interests of science.
  - These curricula acknowledge that students have other disciplinary interests but do so for the purpose of manipulating those interests to meet the traditional objectives of science education.
  - Thus, these other disciplinary interests become paths to science and the paths are clearly secondary to the destination, which is science.

Old School Chemistry

- Curriculum generally includes traditional laboratory exercises that were developed decades ago
- Content is based off of books that haven't changed their "theme" in decades, either!
- Conventional teaching techniques are static and fail to provide interactive environments

How Do We Fix This?

- We need to re-envision the context of chemistry, it's purpose for existence, it's reason for requirement.
- We need to bring life back to chemistry through relevancy to life and living.
- We must flip the message: Chemistry supports all other things, not that all other things support Chemistry!

Students As Learners

- Students need to know *why* they need to learn something.
- They approach learning as *problem-solving*.
- They learn best when the topic is of *immediate value*.
- They need to learn *experientially*.

"What I hear, I forget;
what I see, I remember;
what I do, I know."

What is Active Learning?

- The mission for higher education should be to bridge the gap between theory and practice.
  - Sullivan, W. M., & Rosin, M. S. (2008). *A new agenda for higher education: Shaping a life of the mind for practice* (Vol. 14). John Wiley & Sons.
- What is active learning?
  - As diverse as group problem-solving, worksheets or tutorials completed during class, use of personal response systems with or without peer instruction, and studio or workshop course designs.
    - Cooper, M. M. (2016). It Is Time To Say What We Mean. *Journal of Chemical Education*, *93*(5), 799-800.

What *Should* Active Learning *Actually* Be?

- Restructuring the classroom to increase interdisciplinary content and improve relevance for students.
- Integrating practical and hands-on experiences into curriculum to substantially increase critical thinking in students.
- Ask your students “why” not just “how.”

"Why Do We Need to Learn Chemistry?"

- The dreaded student question.
  - But our answer is just as dreadful: "It's the basis of everything!"
- It's like asking someone to explain "infinite."
  - Too big, too cumbersome, not relevant to every day life.
- Your answer must be more relevant! How?
- Cue Social and Environmental Justice…

Social Justice

- Social justice is a point of view that contends that everyone deserves equality in economic, political, and social rights, as well as equal access to important human rights.
- It is a movement that emphasizes equality of treatment of all kinds, among them issues of environment and health, safety, socioeconomic issues, justice, etc.

Environmental Justice

- Environmental Justice is the fair treatment and meaningful involvement of *all* people with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies.
- It encompasses areas not just related to the environment and ecology but also to civil rights, indigenous rights, labor, food, climate, culture, civility, immigration, and economics to name just a few.

Green Chemistry and Justice

- Green chemistry is the philosophy that chemicals should be designed to limit harm *before* they are produced.
- Imagine the justice potential with a world that has less harmful chemicals: less *disproportionate* exposure to children, minorities, economically disadvantaged populations; less class division for health advantages; and more relevancy for students learning chemistry.

Teaching Example #1

- Lesson Plan: Heavy Metals or Ions
  - Show the video Lead Astray (2015) about how lead increases crime rates in inner city youths and how in a study of Cincinnati children, those with a blood lead level up to ten micrograms/dL lost on average of seven IQ points.
    - Discuss forms of lead, where lead is found, and how lead interferes with calcium ions in neurons.
    - Then discuss how this affects people unequally: are people in depressed urban centers violent by choice or is it the lead in their sub-standard housing?

Teaching Example #2

- Lesson Plan: Oxidation/Reduction
  - Investigate Lead and Flint, MI.
  - Why not implement corrosion control treatment to keep the Pb(IV) from being reduced to more soluble Pb(II)?
  - Ethical and Justice Debate: City couldn't afford upgrade to do corrosion control. Why not? State didn't "care" about Flint residents for 2 years suffering? But MI governor's rep stated they "weren't required" so didn't do it. Which one? At the expense of whom?

Teaching Example #3

- Lesson Plan: Polarity
  - Frame the discussion about polarity in terms of chemical movement into the body through cell membranes.
    - Cell membranes are made of phospholipids, which makes them largely soluble to lipids.
    - Many pesticides are lipophilic (because the chemical has to get inside the bug or plant's cells to work! So it gets into ours, too).
    - Have students look at various molecular structures and predict whether they would get into our bodies, then have them find out if they are toxic or not! (SDS Analysis).

Conclusion

- Conversations of social issues are HARD but REQUIRED to develop socially-conscious individuals.
- Creating scientific relevancy for students empowers them to be change agents!
- Free radicals have revolution y – be a free radical!