OPEN FOR DISCUSSION

Applying What You Learn

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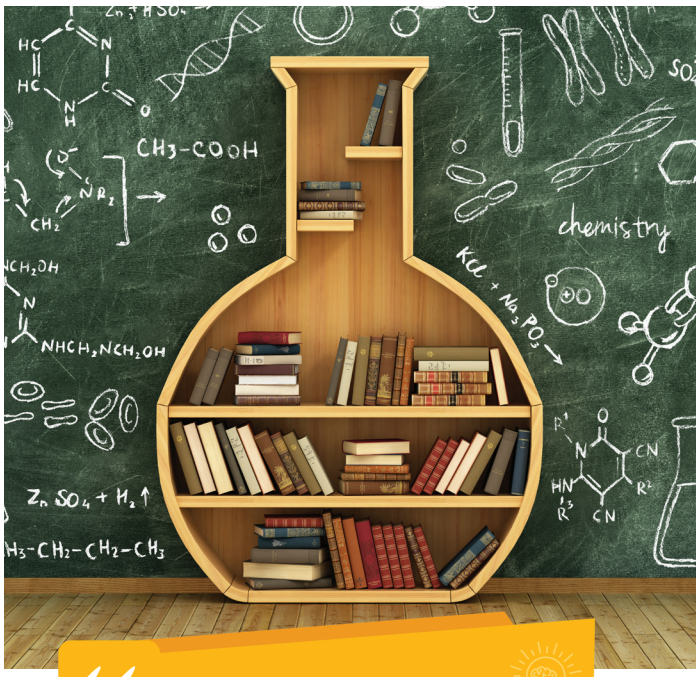

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> "Knowledge without application is simply knowledge. Applying the knowledge to one's life is wisdom—**and that is the ultimate virtue.**"
> —Kasi Kaye Iliopoulos

There has always been a perceived chasm between book learning and practical experience. This is particularly true in the study of chemistry, where nearly all learning is abstract and little of the actual nature of a chemical change is directly observable. We rely on models and secondary effects to infer what must be going on at the atomic or molecular levels. We observe the result of atoms doing their thing, but never see the atoms.

At times, the examples and laboratory exercises use materials that are unfamiliar in students' everyday experience, such as acetic acid or magnesium ribbon. We also tend to focus our instruction on the general rules governing the nature and changes that occur in matter. We teach gas laws and acid base theory, but all too often it stays in the realm of theory, rather than serving to illustrate how the chemistry works in everyday life.

Mostly, students tend to separate what happens in school compared to what goes on in the rest of their lives. Schools are bound by rules and behavior that might not be typical of students' everyday lives. For that and other reasons, students may compartmentalize what they learned in school and may not apply what they learned to make decisions in the rest of their lives.

I had a painful experience recently with my daughter, who I taught in high school for two years, once in introductory chemistry and later as a senior in advanced chemistry. One weekend she complained of an upset stomach.

We did not have any appropriate medicines on hand, so I suggested a bicarb-of-soda, a mixture of baking soda—sodium bicarbonate—and water. She immediately saw how this could help, but she was worried about how it might taste. So instead of dissolving the sodium bicarbonate in plain water, she decided to mix it with orange juice.

It did not take long for me to pounce on her error as we watched the solution foam and froth. To her credit, my daughter immediately recognized that dissolving the sodium bicarbonate in the acidic orange juice had neutralized its ability to act as an antacid in her stomach. She simply had not thought to apply what she knew in an everyday situation. Though, I'm sure she'll remember now!

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In another case, graduates of MIT and Harvard, both in Cambridge, Massachusetts, were asked if they could make a light bulb light up with only a piece of wire and a battery. The results were posted on YouTube. Those on the video expressed confidence that they could to it, but most fumbled with the materials and eventually failed. All this despite having a great background in the fundamentals of electricity and circuits.

Thinking and problem solving is sometimes left out of our science instruction. Many textbook exercises involve applying an algorithm or formula. Lab experiences are often loaded with instructions like cookbooks.

But at its best, science education avoids all the pitfalls of being reduced to mere book learning and concentrates on the most important aspects of science—the ability to think critically and apply abstract concepts to new situations.

There are examples of great instruction in chemistry classrooms all over the country. One exemplar is the final exam for the U.S. National Chemistry Olympiad program. This exam has included a lab practical section as part of the test for many years.

The lab practical is a direct test to see if students can apply what they learn. For example, in 2022, the first question was, "*Antacids are a class of medications that neutralize acid in the stomach. Can you determine the moles of HCl, simulating stomach acid, that can be neutralized by a tablet of commercial antacid?*" Students were given an appropriate set of solutions and equipment to solve the problem, but crucially, no instructions or protocols! You can be certain that no orange juice was involved.

Applying what we learn takes practice and intention. The best learners not only see how to master the concepts, but how they relate to everyday life. How many of us are able to do this? That is open for discussion.