2011 NSTA LHS Pathway Session:

Green Chemistry: Using Chemistry Knowledge to Inform Societal Decisions

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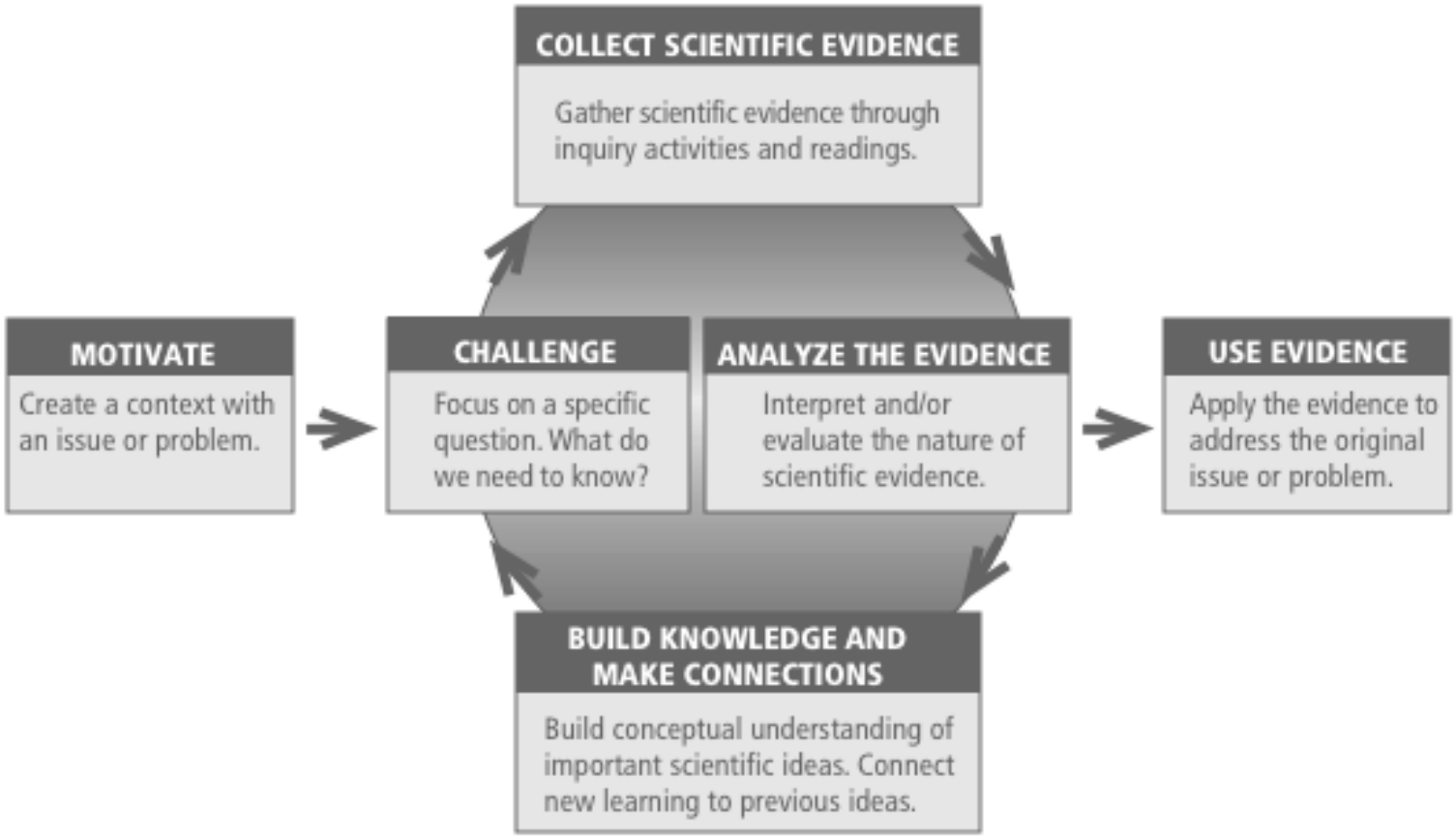
SEPUP's Instructional model for issue-oriented science



Which of three materials—aluminum, glass, or plastic—would make the best drink container?

Please write down your choice of material and your reasons.

How is this a societal question?

What are some of the properties that make the material you chose the best choice?

Please write down some chemistry knowledge or questions you would expect to emerge.

Doing the Activity

- This activity is an opportunity to work effectively in groups. (See GI Scoring Guide.)

- You will sort and categorize information about each of the three materials.

- Work in a group of four, following Procedure Steps 1–8. Your material data cards are in your activity packet.

- We will not do Step 9.

Follow-up

- Review the Analysis Questions.
- Question 5 is an assessment for students' ability to use evidence and trade-offs to make a decision. The evidence and trade-offs scoring guide is on the front of the next-to-last page in your packet (TR-177).
- Discuss with a partner what you would expect in a satisfactory answer to Question 5.

5. [ET ASSESSMENT] What do you think is the best material to use to make drink containers? Write a letter or prepare a presentation to the president of the drink company describing your recommendation.

Support your answer with evidence and identify the trade-offs of your decision.

Level 3 Response (See Teacher Page B-10)
I recommend that the company use aluminum for a new beverage container. I think aluminum is the best because it is recyclable. Also, people who use the cans are more likely to recycle them since half of all aluminum cans are recycled, but only about 29% of glass bottles are recycled. This means more aluminum gets recycled. Recycling aluminum saves energy because it can be used to make more drink containers, which means there will be less sitting in a landfill. Plastic can only be recycled once, so even if it is unbreakable and inexpensive to make, this is not a good trade-off. Making aluminum does create a lot of pollution, but recycling one ton of aluminum means you reduce the amount of red mud, carbon dioxide, air pollutants, and other solid wastes made from getting the raw materials for aluminum. In my opinion, aluminum is the best choice for a new drink container.

Activity 13

- **How did Activity 12 make you think in new ways about manufactured products such as drink containers?**
- **Materials scientists and engineers talk about the "life cycles" of manufactured products. If one of the containers, such as the glass bottle, could talk about its "life," what would it say?**
- **Read the life cycle of a glass bottle on student pages B-8 and B-9.**
- **The life cycle is diagramed on Transparency 13.1.**

Some Green (Sustainable) Chemistry Guidelines

- It is better to prevent waste than to clean it up after it has been created.
- New products should be designed to use inputs and create outputs that are not toxic or hazardous.
- Energy use should be minimized.
- Manufacturers should use raw materials that are renewable instead of resources that cannot be replaced.
- Materials should be designed so tht after being used, they break down or can be reused and do not end up in landfills.

Green (or Sustainable) Chemistry Guidelines

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Twelve Principles of Green Chemistry *

GREEN CHEMISTRY

1. **Prevention**
   It is better to prevent waste than to treat or clean up waste after it has been created.
2. **Atom Economy**
   Synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product.
3. **Less Hazardous Chemical Syntheses**
   Wherever practicable, synthetic methods should be designed to use and generate substances that possess little or no toxicity to human health and the environment.
4. **Designing Safer Chemicals**
   Chemical products should be designed to effect their desired function while minimizing their toxicity.
5. **Safer Solvents and Auxiliaries**
   The use of auxiliary substances (e.g., solvents, separation agents, etc.) should be made unnecessary wherever possible and innocuous when used.
6. **Design for Energy Efficiency**
   Energy requirements of chemical processes should be recognized for their environmental and economic impacts and should be minimized. If possible, synthetic methods should be conducted at ambient temperature and pressure.
7. **Use of Renewable Feedstocks**
   A raw material or feedstock should be renewable rather than depleting whenever technically and economically practicable.
8. **Reduce Derivatives**
   Unnecessary derivatization (use of blocking groups, protection/ deprotection, temporary modification of physical/chemical processes) should be minimized or avoided if possible, because such steps require additional reagents and can generate waste.
9. **Catalysis**
   Catalytic reagents (as selective as possible) are superior to stoichiometric reagents.
10. **Design for Degradation**
    Chemical products should be designed so that at the end of their function they break down into innocuous degradation products and do not persist in the environment.
11. **Real-time analysis for Pollution Prevention**
    Analytical methodologies need to be further developed to allow for real-time, in-process monitoring and control prior to the formation of hazardous substances.
12. **Inherently Safer Chemistry for Accident Prevention**
    Substances and the form of a substance used in a chemical process should be chosen to minimize the potential for chemical accidents, including releases, explosions, and fires.

* Anastas, P. T.; Warner, J. C.; Green Chemistry: Theory and Practice, Oxford University Press: New York, 1998, p.30. By permission of Oxford University Press.

What next?

- Chemistry of materials: Physical and chemical properties
- Application of learning to computers

Eighty percent of old cell phones and computers are thrown away and end up in landfills. That is 350,000 cell phones and 130,000 computers every day! These items contain dangerous chemicals and heavy metals, which can pollute the groundwater.

For example, an old (CRT) computer monitor can contain up to 7 lbs (3kg) of lead, as well as other toxic materials. Electronics also contain small amounts of precious metals, such as gold, so recycling seems like a good alternative. However, recycling means dismantling the items which is time-consuming and expensive. Electronics are often sent overseas because labor is cheaper, but there is often little regard for human safety in handling the materials. Some retailers and manufacturers offer free recycling but the cost of dismantling the items is still an issue.

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