

Teacher Guide

Lesson overview:

The goal of this lesson is to introduce students to the 12 Principles of Green Chemistry and how it relates to a chemical process. Before completing this activity, you would want to be sure your students have had an introduction to the periodic table and properties of matter.

The objectives of this lesson are to introduce students to the ideas of toxicity and environmental impact as properties of matter, give students an introductory understanding of the basics of the 12 Principles of Green Chemistry, use mass and measurement to understand the concept of a recipe as it is applied to a chemical process, and to give students an opportunity to think critically about a process and how it might be improved upon.

The estimated time required for this activity is 60 minutes. You could divide this up into two segments if that fits your schedule better. For example, you could complete the lesson through the glue-making activity and have students test the glue by using it to glue some paper overnight. Then, you could come back the next day, test the efficacy of the glue by checking how well it glued the paper, and then complete the lesson starting with the brainstorming activities of segment 4.

The core of this lesson is in working through a poorly written procedure and having students redesign the procedure in a way that makes more sense to them. By doing this, the students will naturally make the process more efficient and less wasteful than what was given to them. By asking the students to explain why they made each of the changes they did to improve the procedure, your class will be able to pull out simplified versions of the 12 Principles of Green Chemistry together.

During Activity 3, the class may go through this procedure in pairs or if it is more convenient they could work in groups of up to four students. The students will likely protest some of the steps, saying that they're silly or pointless, but do your best to get them through the entire procedure. However, you know your class best, so if you must stop the procedure before it is completed, do so and begin Segment 4 so you can move on to Activity 4 in which the students will rewrite the procedure.

During Activity 4, the students will go through each step and rewrite the process. Allowing the students to work in pairs or individually will allow them to really think critically about improving the process. When the students have finished this task, go through the revised procedure as a class (allowing different groups to share one step each) and have students identify the reasoning behind the changes they've made.

Activity 5 will be where you begin to draw out the take home message. Together, let the students brainstorm a list of ways that their new version either minimized the

impact on the Earth or maximized the conservation of materials or energy. You might want to have them list these on the board. This is the list from which you will draw out the 12 Principles of Green Chemistry. Some of the Principles are more difficult to pull out from your class (like Principle 8: Reducing Derivatives), so you may need to prompt them more to identify the more challenging principles. Alternatively, you might decide to only focus on the principles that you know your students will be able to come up with and understand, and then simply give the more challenging principles like number 8 and tell them they will understand these more when they have had more experience as chemists.

In Segment 6, the video introduces the 12 Principles and showcases how the students have likely already drawn these out of the process they just went through. The principles were written for use in complex scientific processes, so they can be difficult to understand or explain. Because of this, it will be helpful for you to read the supplemental information provided in the Teacher Background information on the 12 Principles that breaks down the principles into easier to explain concepts. Though the principles may be complex, the process of applying them is the same as what your students used to improve the recipe.

Helpful tips:

This lesson, as well as all lessons available on the Beyond Benign website, is available in Word format so that you may easily download the lesson and alter it to make it your own. For example, when some teachers do the glue making activity with their students they substitute in materials that they have readily available, such as fat-free milk rather than skim milk powder, and anything that can lend itself to the red dye. For example, if you have peppermints leftover from Christmas, you can use those! Teachers often leave out the glitter because it tends to be messy, and some teachers never use the centrifuge tube or the ventilation hood. Ultimately, the only critical components of the recipe are the milk, vinegar, and baking soda. You will find that each time you do the activity, it might look a little different depending on what you have available at the time. This lesson and activity can be applied at different points in your curriculum and with different types of classes. It can be used in relationship to the introduction of biomimicry, and when introducing the concept of the 12 principles. You may also want to have students compare the efficacy of the homemade glue to store-bought glue so that you can discuss the importance of the fact that a green product must work as well as the traditional product. You can also have students do a cost comparison.