Teaching concepts of 'scale-up' from chemistry to chemical engineering using process flow diagrams (Resource Exchange)

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Resource Exchange – Handout

Title:	Teaching concepts of 'scale-up' from chemistry to chemical engineering using process flow diagrams
Target Grade Level:	6-8
Target Age Range:	11-14
Expected Time-Frame	3 hours
Learning Objectives	Material properties, Chemical Reactions, Engineering Design
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Activity Summary

One of the key tasks for a chemical engineer is to facilitate the plant design process, and transform lab-scale chemical reactions to full-scale chemical plants. To do this, the chemical engineer must understand the properties of all of the components in the chemical reaction process as well as the relevant chemical engineering equipment for plant design.

This activity is designed to introduce the fundamentals of chemical engineering and process engineering as well as concepts of materials engineering. The activity is targeted towards grades 6-8 students (ages 11-14) but can be adjusted and modified for younger or older audiences.

The activity can be broken down into 3 components: materials, chemical and process engineering. Each of the components asks students to use various aspects of critical thinking, problem solving and design thinking, while applying fundamental knowledge of math and chemistry.

The first component of the activity looks at the material properties of certain substances and leads into the second component, allowing students participate in a simple chemical reaction that will result in a product with differing material properties. The third component looks at engineering design and introduces the Process Flow Diagram (PFD).

Overall the activity will introduce the following concepts: Material properties, Reactants and Products, Basic Chemical Engineering Equipment, and Process Flow Diagrams (PFDs).

The premise of this activity centres on a chemical reaction. It can be done with any reaction that contains reactants with differing material properties from their product. This handout will include the polymerization reaction using water, glue, and Borax to create ***'slime'***, as well as the saponification reaction of lye and fat to make soap.

Method Summary

Part 1 – Material Properties

The activity begins by looking at the different material properties of household objects. Students are given an object and asked to look at all the properties of the material it is made of and how that material property is beneficial for the use of the object.

Some examples of materials properties are: *soft, hard, flexible, waterproof, rough, smooth, lightweight, heavy, liquid, solid, bouncy, stretchy, etc.* Students will list these properties in pairs or small groups and then be asked to share with the class.

To test their understanding, different objects will be presented such as 'basketball' or 'chair' and students will be asked to choose a type of material that would be best for this object. This will reinforce the idea of choosing materials based on their properties for specific uses.

Part 2 – Chemical Reaction

The students will then each be given instructions on how to complete a chemical reaction.

They will note the material properties of each of the ***reactants*** separately and the potential uses of each reactant. They will discuss how the properties of the material makes it effective at what it is used for. After the reaction takes places students will note the material properties of the ***product***.

They will then be asked to come up with a viable use for the product based on the material properties. Optional assessment can be done on the feasibility of the product use chosen.

Part 3 – Process Flow Diagrams

Finally, the idea of 'scale-up' is introduced, performing chemical reactions on a large scale to produce large quantities of a product, as well as the concepts of process engineering, designing the components of a process from start to finish. Basic engineering equipment is introduced, along with examples of process flow diagrams (PFDs) and the corresponding PFD symbols for each piece of equipment.

The purpose of each piece of equipment is discussed and how it relates to similar lab-scale equipment that was used to complete the chemical reaction. Students will then work in groups to determine which equipment would be useful to 'scale-up' the chemical reaction based on the properties of the reactants and products, as well as which order the equipment would be needed based on the steps used to complete the chemical experiment.

The concept of using instrumentation for process control can also introduced depending on grade level, and students can reflect on the importance of proportions when scaling (flow/level indicators) as well as the reaction conditions (temperature/pressure indicators).

This conversation will then lead to the students making a process flow diagram of the chemical reaction they previously completed. Assessment is done on the understanding of the chemical engineering equipment and use of PFD symbols.

***Additional information containing handouts for students with examples of PFDs for slime polymerization and soap-making/saponification can be found on the BrainSTEM Alliance website or by contacting info@brainstemalliance.com .*