# Engineering Better Bubbles:

## *Chemical Engineering and You*

Presenters' Manual

2003-2004

K–12 Engineering Outreach Program

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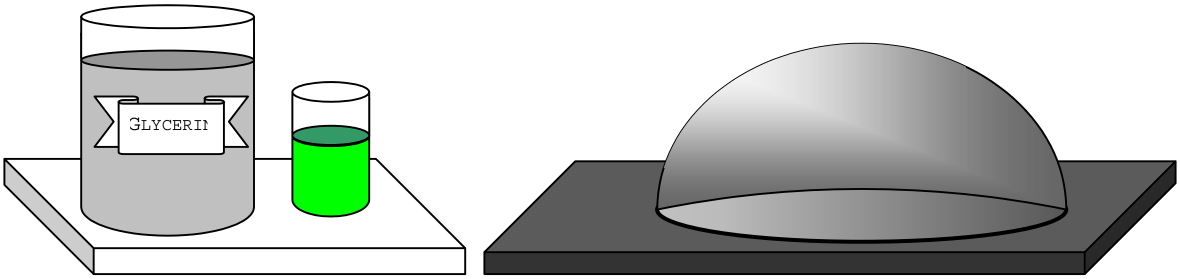



## Using This Presenters' Manual

The key to doing effective Outreach presentations is finding the right level for your audience. Children hate being talked down to. No one likes being lectured to.

You must interact with your audience; find out how much they already know and build on that.

This manual is meant only as a guide and will not completely prepare you to give this presentation. In order to deliver this presentation effectively you must **practice** and have a strategy. Think about the **purpose** of this presentation and understand your **audience**.

To use this guide, read the first section, which gives some basic goals and theory behind the **K-12 Outreach** program. This information will be useful and might help you determine what things you should prepare for. The next section in the guide is a basic outline that explains the content of each portion of the presentation. The third section explains the presentation and what each section should try to accomplish. The final section contains the kit inventory and an appendix with reference materials for you and for your audience members.

## K-12 Outreach Mission

**THE K-12 OUTREACH PROGRAM** sends undergraduate students to area schools to talk about careers and training in technology and science while demonstrating some of the ways in which engineers are changing our world.

☛ **The mission** of the K-12 outreach program is to improve science and engineering literacy, to engage and interest school children and their teachers, to expose undergraduate students to outreach and to its rewards, and to make science and technology fun.

**We want to turn kids on to science, math, engineering, and technology!**

## Purpose

The goal for this presentation is to introduce school children to chemical engineering in a fun and interactive way. The fundamental idea is that **the chemical composition of a material affects its behavior**. The chemicals involved are common ones: water, dish detergent, and glycerin. The material is one of every kid's favorites: bubble solution. The challenge is to associate the fun of playing with bubble solution with chemical engineering.

You will be representing the engineering component of the presentation. The students will likely have many questions. Don't feel pressured to answer every question. Do the best you can and if you get stuck, don't make up an answer. If you get question that you can't answer, refer them to some other sources or web sites.

## Audiences

☛ **KNOW YOUR AUDIENCE!** Different age kids have different interests, values, attention spans: consider your audience before you start to talk. You can tailor this presentation to a variety of different audiences:

YOUNGER CHILDREN: Keep things short, simple and interactive. Younger children have a shorter attention span and will relate better to things that they can see. Try to give them examples that they might see every day. Make sure that you give them time to think about a question before you answer it for them. Let them formulate their own ideas about everyday phenomenon. The hands-on interaction is very important in this age group. You will need to downplay the quantitative side of the presentation and concentrate on the qualitative experience.

MIDDLE SCHOOL CHILDREN: Children at this age are still learning abstract thinking and have a better idea of how things work around them. With this age group, the children will be able to understand more complex theories and explanations so a slightly more advanced delivery is appropriate. These students can handle the quantitative and numerical side of this presentation, and may even enjoy associating numbers with their more qualitative experience. It is also important to understand that children at this age are often shy and feel awkward or uncomfortable and may be easily embarrassed. Be patient with these children and don't let a single person dominate the discussion. Try to involve as many people in the discussion as possible.

HIGH SCHOOL STUDENTS: For these students, this presentation should be geared more towards engineering as a career and less toward the particular activities. In a presentation for older students the use of the hands-on activities should be scaled down. The presentation still needs to be interactive but the activities should be a basis for discussion. Students in their teens will be much more interested in what college life is like. Don't step around things. Tell them that college, especially engineering, is hard and is a lot of work, but make sure to be positive about it too. **Speak from your own experience.**

☛ No matter which age groups you talk to, as part of your introduction, talk about your own experiences as a student at the University. It is important for kids to meet you and to hear what you have to say. When you introduce yourselves, tell them why you went into a technical field and what it is like being at a school like the U. W.  Encourage the kids to ask questions about college life and answer them as honestly and completely as you can.

***These presentations depend heavily on your enthusiasm and energy to be successful. If you can communicate your enthusiasm for your chosen field, you may be a real help to a younger person who is trying to decide what to do with his or her life.***

## Overall Hints

1. Do **not** read this like a script, use it as an outline. Be creative and add your own personality.
2. Interact with the kids: Ask lots of questions to get your audience to think about your topic. Turn statements into questions. Make every effort to make this a dialogue, not a monologue.
3. Before you start talking, put the props on a table in the general order in which you would like to present them (left to right). This will help you remember what and how you want to present.
4. Do **not** cover all this material during your ~45 minute presentation. If you do, you are: going too fast, using terminology without explaining it, not adapting your presentation to your young audience and/or not asking enough questions. Be creative.
5. Define technical terms: let the kids try to guess, but make sure you give them a clear definition before you move on.
6. Comments such as, "write on board" are suggestions; please feel free to do what seems appropriate.
7. Have fun. If you are having fun, the kids pick up on this and they will have fun too.
8. Use the teacher as a resource: find out how much the kids have already covered in school, ask for help if you have trouble explaining something or answering a question, turn to them for assistance if there is a behavior problem.
9. Keep track of all the items from the kit and collect them all before you leave. Give teachers this number where they can call the Coordinator if you left something behind: **608 262-6945**
10. Use the website as a resource: ***http://ysa.engr.wisc.edu***

## Use Visual Aids

☛ Keep things as visual as possible so that the students can see what you're talking about. Write words out, draw pictures and use diagrams.

☛ **Be Energetic!** Show them why you are excited about chemical engineering and show your enthusiasm for it. The more energy you put into this presentation the better it will go. Talk about what you know.

## Suggested Outline: Chemical Engineering Presentation

**I. Preparation**

A. Ask teacher for help setting up student groups
B. Give teacher evaluation forms
C. Get water for presentation
D. Set up workstations

**II. Introduction (5 minutes)**

A. Identify presenters: Names and majors Why are we here
B. What is chemical engineering
What do chemical engineers do? Show examples
C. Example of chemical engineering process: making hot cocoa
Listing and gathering ingredients
Adding heat
Changing the recipe: extras and modifications
Use flow chart to show process

**III. Discussion: The chemistry of bubbles (5-10 minutes)**

A. What is a bubble?
B. Adding detergent to make bubbles last
C. Adding glycerin to make bubbles bigger

**IV. Experiment: Engineering bigger/longer-lasting bubbles (20-25 minutes)**

A. Demonstrate the method
B. Divide into groups
C. Make measurements

**V. Conclusion: Collecting the Results (5-10 minutes)**

A. Examine the data collected
B. What do the measurements say?
C. Summary:
What chemical engineers do
What chemical engineering students study
Importance of learning scientific method and math

**VI. Clean up**

## Before You Go

- ☛ Before departing for the presentation, prepare the detergent solution.
  1. Fill the 1/2-gallon jug nearly full with water.
  2. Add 1/2 cup of dish detergent to the water.
  3. Cap the jug tightly. Don't shake the jug; you don't want to make suds!
  4. Gently invert the jug repeatedly until the liquids are mixed.

- ☛ Label each of five one-pint containers: 0 drops, 10 drops, 20 drops, 30 drops, and 40 drops with the marker. (The remaining container is for your demonstration during the presentation.)

- ☛ Before departing for the presentation, make copies of the data sheets.

- ☛ Before the presentation, talk to the teacher to learn how things are done in the classroom. Let the teacher know what you will be doing and what help you will need. Discuss with the teacher the general outline of what you will be doing, and try to assess the level at which you should make the presentation.

# I. Preparation when you get to the classroom

A. Ask the teacher to divide the class into three to five groups. The teacher is the best person to do this because the teacher knows the students and which ones work better together.

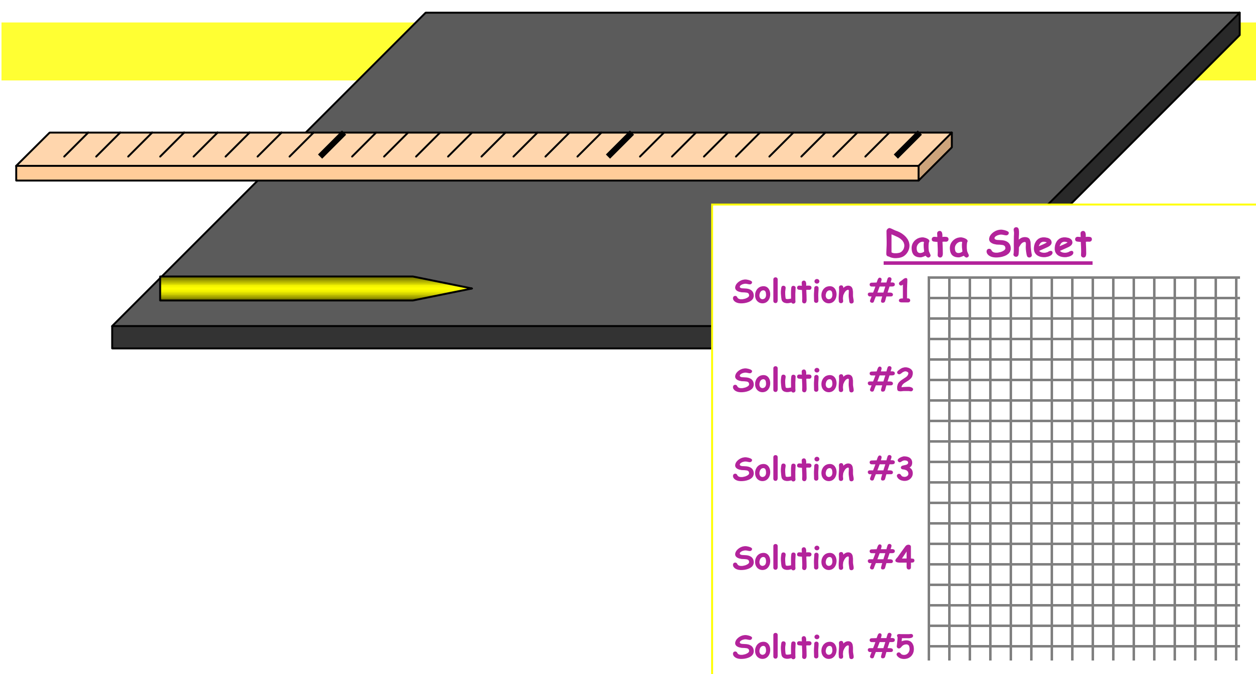
B. Give the evaluations to the teacher and explain that they may be completed at the teacher's convenience. Ask him/her to write general comments on the back and to mail them back to the Coordinator.

C. Pour $^1/_2$ cup of the detergent/water mixture from the jug into each of the five labeled containers. Fill the water pitcher with water.

D. Set up the workstations before you begin, so they are ready when the student activities begin. If possible, distribute the workstations around the room, so students can get at them from all sides.

☛ Put the white shower curtain under acrylic to catch spills.

☛ Each work station should have a sheet of acrylic, a meter stick(yard stick), a pencil, and a data sheet for each. (For young students, the data sheet can be a roll of paper tape and a box.)



## II. Introducing The Presentation

**A. Introduce yourselves and explain why you are there.**

Write your names on the chalk board.

☛ Ask questions to get an idea of what the students already know: ask them if they know about engineering and about chemistry, what they know about atoms and molecules, or if they know how the properties of molecules affect the properties of materials.

***Who knows what a chemical is?***

***Does anyone know what an element is?***

***What is a mixture?***

☛ These questions will give you an idea of the level of the audience, and help you decide at what level to make your presentation.

**B. What is chemical engineering**

***What do chemical engineers do?*** **Show examples**

☛ Chemical engineers use chemistry to make better products or to make products more efficiently. Therefore, chemical engineers need to know about chemistry (atoms and molecules) and about how different combinations of chemicals affect the way products work.

☛ Examples of some things chemical engineers do:
Show plastics and other products. Talk about how someone came up with idea for improving product or process. Chemical engineers experimented until they hit on a way to solve problem.

**C. Example of chemical engineering process: MAKING HOT COCOA**

☛ Have the kids help you come up with a process description for how you make hot cocoa:

**Listing and gathering ingredients**
**Determining correct proportions and quantities**
**Adding heat**
**Mechanical process: stirring the mixture**

☛ **Changing the recipe:** ask them what you could do to make the cocoa better. Talk about extras and modifications, like adding marshmallows or using milk instead of hot water.

**Use visuals: a flow chart to show process**

☛ Chemical engineers study how combinations of chemicals affect a product—we will work with a soap bubble solution. Although this is perhaps not a very important product for society, it is fun to work with and can show some of the things chemical engineers do.

# III. The Chemistry Of Bubbles

**Bubble solution** is a product that depends on chemistry. Bubble solution contains several chemicals. Explain that what the students will do today as chemical engineers is to see what proportions of these chemicals produce the biggest and longest-lasting bubbles.

## A. What makes a bubble?

**Surface Tension results from water molecules sticking together**

DEMONSTRATION: Have a student blow through a drinking straw into a glass of water to show how bubbles are formed.

☛ **Ask:** ***what is a bubble?***
It is gas (air) surrounded by a liquid (water).
***Do the bubbles in water last very long?***
No, they disappear as soon as the bubble reaches the surface of the water.

☛ Ask the students to name other substances that form bubbles that last longer. Possible answers include soap, cream, eggs. These things contain water, but also contain other things, too.

**Why bubbles in water do not last very long.**

DEMONSTRATION: Place a drinking glass at eye level for the group of students. (The students may crouch around the table to get the glass at eye level.)

**How can we get the water molecules to spread out instead of forming drops?**

☛ Pour water into the glass until it is full to the brim.
Add more water, drop-by-drop, until the surface of the water is higher than the rim of the glass. Make sure the students can see that the water is higher than the glass.

☛ **How can the water be higher than the brim of the glass?**
Ask the kids to come up with an explanation. Older kids will know about surface tension.

☛ The water does this because its molecules stick together. Because water molecules stick to each other, water forms drops instead of spreading out.

DEMONSTRATION: Put a few drops of water on the table top to show how water forms drops. Bubbles in pure water do not last, because the water molecules come together into a drop, not stay spread out around a bubble.

Help the kids reach a conclusion based on this demonstration: **If we want to make a bubble, we have to find a way to get the water molecules to spread out instead of sticking together.**

## B. How can we make bubbles last?

**Detergent will keep the water from sticking**

We can add something to water so the water molecules do not stick together so well. Soap or detergent will do this.

**DEMONSTRATE** what happens when a single drop of dish detergent is added to the over-full glass of water. The water will overflow the glass and run down the side.

☛ Ask the kids if they can form a hypothesis about why this happens: Because the water molecules no longer stick together so well, water with detergent in it will form longer lasting bubbles.

**DEMONSTRATE:** Pour some of the water out of the glass, adding a few more drops of detergent, and then blowing though the straw into the glass. A froth of bubbles will form.

## C. How to make bubbles bigger.

**Adding detergent to the water makes the bubbles last longer**

☛ Explain that the jug contains a mixture of water and dish detergent that you made earlier. Pour some of the mixture into one of the pint containers, and use it to blow some soap bubbles with the bubble wand. These bubbles will be rather small and not last very long.

☛ They do not last long because the water in the bubble evaporates. If we add something else to the mixture that will slow down the evaporation, the bubbles will last longer and get bigger.

**Glycerin slows down evaporation**

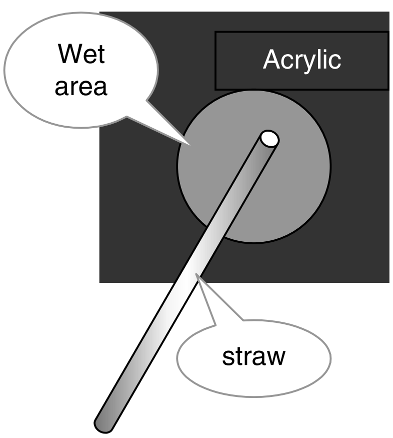
☛ A material that will do this is glycerin. The molecules of glycerin are slightly sticky toward water molecules, and they slow down the evaporation of water.

# IV. ENGINEERING BIGGER BUBBLES

## A. Demonstrate the method

Tell the students that they are going to engineer better bubbles by investigating how the amount of glycerin affects the size of the bubbles. They will use the soap solution you just made. You will set out five different samples of the soap solution with different amounts of glycerin in them. The students will compare the size of the bubbles that each mixture makes. This way they can find what is the best amount of glycerin to use to make big bubbles.

Explain that each of the labeled containers holds the same amount of detergent solution. Add the label number of drops of glycerin to each container. Hold the dropper vertically to reduce variations in the size of the drops. One person (preferably, the teacher) should add the glycerin, so the drops are uniformly sized.
Ask the students to help count the drops. Swirl the containers to make sure the glycerin is dissolved. Place one of the containers at each workstation.




**DEMONSTRATION:** Pour a small amount of the solution from one container onto one of the acrylic sheets, and spread it around with your hand to wet an area about 18 inches in diameter.

☛ Now, demonstrate how the size of the bubbles from each solution is to be measured. Dip a drinking straw into the solution in the container. With the straw just touching the wet acrylic surface, gently blow through the straw to produce a bubble dome. Continue blowing until the bubble pops. (It may require more than one breath.)

☛ A ring of soap suds will be left after the bubble breaks. With a meter stick, measure the inside diameter of the ring of soap suds. • Write down the diameter on the data sheet, and put your initials after it. (With younger students, instead of measuring with a meter stick, they can tear a piece of paper tape the length of the diameter, and put the tape in a box at the workstation.)

## B. Dividing into groups

Distribute the drinking straws, one to a student. Have the groups measure the bubbles from all five solutions. Have the students take turns blowing bubbles, so they don't hyperventilate. Instruct each group of students to measure bubbles from each solution and record their results on the data sheets.

☛ As groups finish with one solution, they should swap work stations with another group. If there is enough time, try to give all students a chance to blow bubbles with all solutions.

☛ Walk around and ask the kids questions: what techniques work best for making big bubbles? Do bigger kids blow bigger bubbles? Does everyone measure bubbles the same way? Can you tell the difference between the different solutions?

☛ Get them to think about the **scientific method**: controlling variables, calibrating measuring devices, running a control group, etc.

## C. Making measurements

During the measuring, students may ask questions such as "This bubble was very small, should I measure it?" or "This bubble isn't round, how do I measure the diameter?" Tell them that they are the engineers and that they should discuss it with other students and agree upon what is fair. Whatever they decide, they should do the same thing with all solutions.

☛ Watch the clock: leave time for a conclusion and don't run over your allotted time!

# V. Collecting The Results And Summarizing

## A. Examining the data collected

After all solutions have been tested, gather the data sheets (or boxes of tape).

☛ Ask the students if they found that one solution made bigger bubbles than the others.

☛ Examine the data that was collected. On the chalkboard, average the diameters recorded on the data sheets for each solution. Let the kids help you with the math.

☛ Younger students can make a bundle of the tapes for each solution to see what size was most common for each solution. See if the data agrees with the impression that the students described. (Sometimes, there is so much variation in the data that no conclusion can be drawn.)

## B. What do the measurements say?

Ask the students what they think caused the variations, and how the experiment could be improved to get more definite results.)

☛ Find out if the results surprised the students. Many students assume at first that the more glycerin used, the bigger the bubbles will be. This experiment shows that this is not the case.

## C. Summary:

***What chemical engineers do***
***What chemical engineering students study***
***Importance of learning scientific method, and math***

☛ This activity is an illustration of the many different kinds of things chemical engineers do. They examine products to see what properties are desirable, like big, long-lasting bubbles. They examine the chemicals that are involved in making products. They measure things and interpret measurements.

☛ You can use the bubble wand to blow bubbles with the five solutions. See if the students can tell the difference between the bubbles from each solution, and if what they see agrees with their measurements.

☛ Thank the teacher and the students for their cooperation.

☛ Remind the teacher to return the evaluation forms.

## Cleaning Up

**At the school:**

1. Pour the leftover bubble solution down the drain and rinse the containers with water.
2. Discard the straws.
3. Wipe off the measuring sticks and the shower curtain.
4. Wipe the acrylic sheets with paper towels to soak up the soap solution and discard the paper towels.
5. Do not use water on the sheets, it will produce lather that is difficult to deal with.
6. Dry them off with the cloth towels.

**When you get back to campus:**

1. In a janitor's sink, rinse the measuring sticks and acrylic sheets with plenty of water and dry them with paper towels.
2. Write note to Coordinator if the kit needs re-supply or repairs

## Contents of the Kit

☛ The kit includes durable items that can be used many times and should always be returned with the kit. These are:

1. five black acrylic sheets - 30″x 30″ x$^{1}/_{4}$-inch
2. 1-cup measure
3. six 1-pint plastic containers
4. five measuring sticks
5. dropper with bulb
6. clear drinking glass
7. water pitcher
8. bubble-blowing wand
9. $^{1}/_{2}$-gallon jug with cap
10. plastic shower curtain liner to contain the mess

☛ The kit also contains consumable items that will need to be replenished as they are used. These are:

1. plastic drinking straws (one per student per presentation)
2. absorbent paper towels and rags
3. masking tape
4. marker
5. glycerin (approximately 5 mL per presentation)
6. bottle of liquid dish detergent