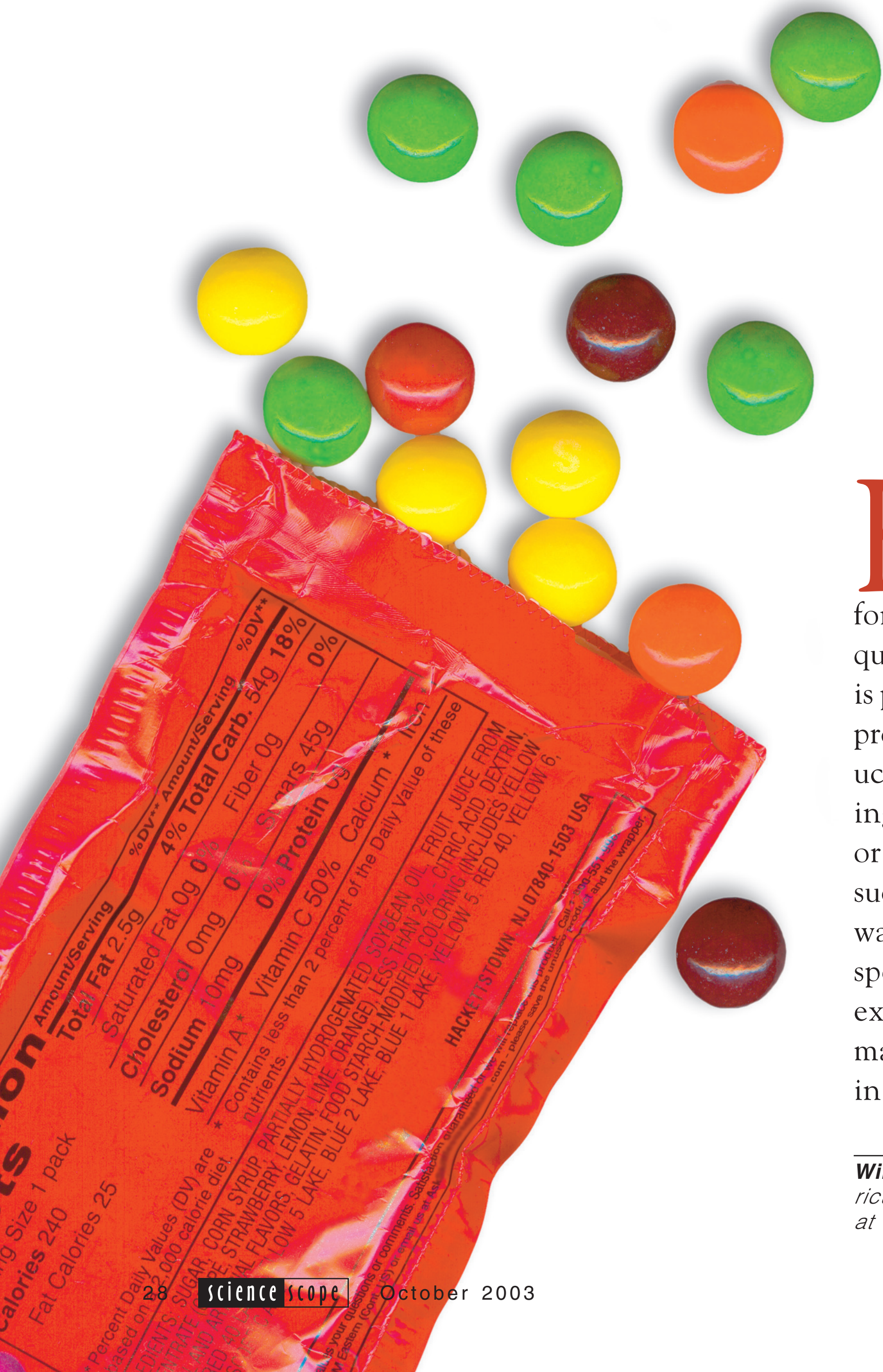
Quality Control & Design in Science Learning



by William J. Sumrall and Don Schillinger

Ever since Henry Ford's vision for the assembly line production of Model Ts, our nation's industries have had a passion for mass-producing products of quality, both quickly and inexpensively. While every effort is put forth to lower production costs and mass-produce, there is a similar effort to ensure products are consistent with regard to manufacturing quality. Be it food, drug, automobile, toy, or anything else, specific manufacturing goals such as consistency of quality and safety are always in the forefront. Our ability to purchase a specific brand of soft drink and have it taste exactly the same in Texas as in Maine is one of many examples of quality control that occurs in the United States.

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One area of science education that is, at times, neglected involves lessons on technological concepts of these principles—designing, testing, and quality control. Instead, a focus upon science concepts from a pure, and unapplied, perspective is the norm. Thus, while students may learn the equation "mass divided by volume equals density," the actual application of the concept within the boat-building industry may be neglected. While learning science for the sake of learning *pure* science has its place, being able to apply principles and relevance to science learning should be a goal if understanding the relationship between science, technology, and society is to occur.

Additionally, introducing quality control, completing multiple activities, and using the concept as a starting point toward inquiry-based learning are worthwhile teaching strategies according to the *National Science Education Standards* (NRC 1996). Specific standards that focus upon the relationship between science, technology, and society can be found across the K–12 spectrum.

The activities that follow are written for the middle level, but can be modified for your younger or older students. As the products selected for testing should be safe for consumers to buy, the actual testing conducted by students in your class should be safe as well. Any safety issues have been noted on the activity sheets.

Introducing the concept

Prior to doing activities that teach design and quality control, begin with a discussion on travel across the United States. Working in small groups of three or four, have students discuss their automobile, places they ate, bridges they crossed, items purchased, places they stayed, and so on. Ask them if they felt safe during their travels. Ask them if some things were the same regardless of where they went. Explain that a number of agencies in a government work to maintain safety for its citizens. Thus, things like bridges are checked before, during, and after construction to ensure safety. If some students mention flying, issues related to flight safety (e.g., Federal Aviation Association), airplane design, and so on can be brought out in a discussion about design. Point out that this system of checks can be identified as design and quality control. Similarly, companies that make things are certainly concerned with safety, but they are also interested in consumer satisfaction. Hence if you drink a soft drink in California it should taste the same as in Florida, or if you eat at a chain restaurant in Washington or Texas the food should taste as good in both places. Product quality, safety, and mass production are concepts related to design and quality control that can easily come out of a discussion with students about their travels.

The activity series

I like to reinforce our discussion and concretely introduce the concepts of quality control and design through a series of activities. Each activity included is relatively inexpensive (to reduce costs you may want to request donations from parents to purchase sodas, candy, and gum prior to initiation of the unit) and works nicely with cooperative groups of three or four. Completion of all activities requires several days and, with the addition of the inquiry-based assignment at the end, the instructional time could increase an additional two to five days. If students do a presentation on their final assignment, the length would also increase. Data sheets for both the initial activities and the inquiry based-design/quality control project can be used as part of the assessment process. A rubric to grade the final project and an optional presentation rubric can serve as additional assessments.

FIGURE 1 **Design and quality control inquiry**

Your group has recently completed several activities focused on design and quality control. Using that knowledge, design and check for the quality control of a manufactured item. Your analysis methods and what you analyze should be safe. Before you begin with your design and testing I would like to know your plan. Specific requirements include:

1. Each group member must collect data that can be quantified, i.e., you need to use an instrument (ruler, balance, thermometer, etc.) to gather data. Don't rely on just your eyesight!
2. What is the product you are testing?
3. How do you plan to test the product for quality control (be specific, include materials needed and step-by-step instructions)?
4. Each group must build a data sheet displaying findings.
5. Each group must provide a materials list prior to implementation.
6. Provide a photograph or diagram of your apparatus or testing area.
7. A final report (minimum of two pages) discussing the product's quality is required. Review a *Consumer Reports* article to get an idea of format and style for doing your final report.

Teacher's approval ______________________________ Date ____________

The first activity has students estimate percentages and count plain candy M&M's by color (see activity sheet on page 31). If students have a chocolate allergy, using Skittles is another option, among several other alternatives. I recommend not using peanut M&M's because of potential nut allergies. The activity provides a good opportunity to discuss quality control issues by calculating if each package holds the same number of M&M's and has the same mass. This will give some insight into the accuracy of the Mars candy measurement machinery. Differences in the total number of M&M's, the mass of the packages, and the color ratios leads to much discussion and speculation. Specifically, students usually want to know why there is such a variance of M&M's by color in each package. Some speculations/suggestions that the students will provide for the variations are cost factors (e.g., one dye color is more expensive than another) or predominate color preference through a survey given to consumers. Students may write to the manufactoring company they are investigating through the website or by mail to get answers to their questions, such as "Why are there more of one color M&M than another in a single bag?" "How are M&Ms placed in the each of the bags?" or "What does your company do to make sure production is safe and efficient?"

In the second activity, students mass sticks of gum, soak them in water overnight to dissolve as much sugar as possible, and then mass the sticks again (see activity sheet on page 32). The procedure may not accurately determine how *much* sugar is in a brand of gum (since all the sugar may not dissolve from a stick of gum in such a short amount of time), but it should tell the investigator that gum pieces consistently hold the same amount of sugar (assuming the rate of dissolving is the same) which is an element of quality control. The activity works best if different groups in the class use various gum brands so the comparisons are more dramatic.

The third activity determines the amount of sugar and other substances within a specified amount of soft drink (see activity sheet on page 33). Working in groups, have students select a brand of soft drink for testing. Place a set amount (I recommend 50 mL or less) in a graduated cylinder, mass the liquid in your observation container and then let it evaporate, leaving behind the sugar and other materials. Dependent on the amount of soft drink used, the shape of the containers, and the temperature/humidity, the rate of evaporation will vary. Hence, you will want to provide several days to complete this activity. Similar masses in several trials indicate that a soft drink company uses good quality control.

Additional activity ideas include comparing foam and cardboard egg cartons with eggs inside by dropping them from different heights as a design and quality control issue, or comparing paper and plastic bags for strength.

Developing an inquiry assignment

After completing several activities that help students understand the concepts of design and quality control they should be able to develop their own investigative study in groups of three to four. Consistently change job roles to ensure all students are participating in the activities. Furthermore, groups should be heterogeneously mixed by achievement in science if at all possible. Analysis for consistency of a product as modeled in the first three activities is a requirement for each group. This project can be both in-class and take-home, but regardless, several days of planning and implementation should be allowed. Also, each group member should be required to collect data. If possible have each group member repeat the testing procedures to corroborate findings, paralleling what scientists/engineers do in the actual work place.

To ensure that safe inquiry occurs, students are required to submit their research plan before they begin for teacher approval. Figure 1 on page 29 shows our approach that has been successful for students in the middle grades. Our approval signature is a requirement before a group is given the "green light" to proceed.

Conclusion

Having students complete these types of activities extends their knowledge of science as it applies to both society and technology. Making these connections meets a major component within the *National Science Education Standards*. Just as important is the fact that concepts studied in pure science are reinforced through the processes involved in studying about design and testing for quality control.

A key for success will be the teacher's ability to facilitate the students' investigations. Bringing out science concepts during activities completed in class (e.g., rate of dissolving, evaporation rate, force, mass, weight, etc.), asking questions that can bring out additional concepts (e.g., density, carbonation, hygiene, etc.) for investigation, and assisting students in their own "personal" investigations meets the criteria of teaching through inquiry. ■

References

National Research Council (NRC). 1996. *National Science Education Standards*. Washington, D.C.: National Academy Press.
Sumrall, W. 2001. Trash or treasure? *Science Scope* 24(4), 28–33.
Sumrall, W. J., and J. Criglow. 1995. The "scoop" on science data: A study of spoons shows students that scientific inquiry is a vital part of their lives. *Science and Children* 32(6), 36–39, 44.

Activity sheet 1—Candy packaging

See if each package among different groups holds the same number of candies and has the same mass to show the accuracy of the candy company's measurement.

Materials (per group)

- one package of candy
- paper towel or plate
- balance

Procedure

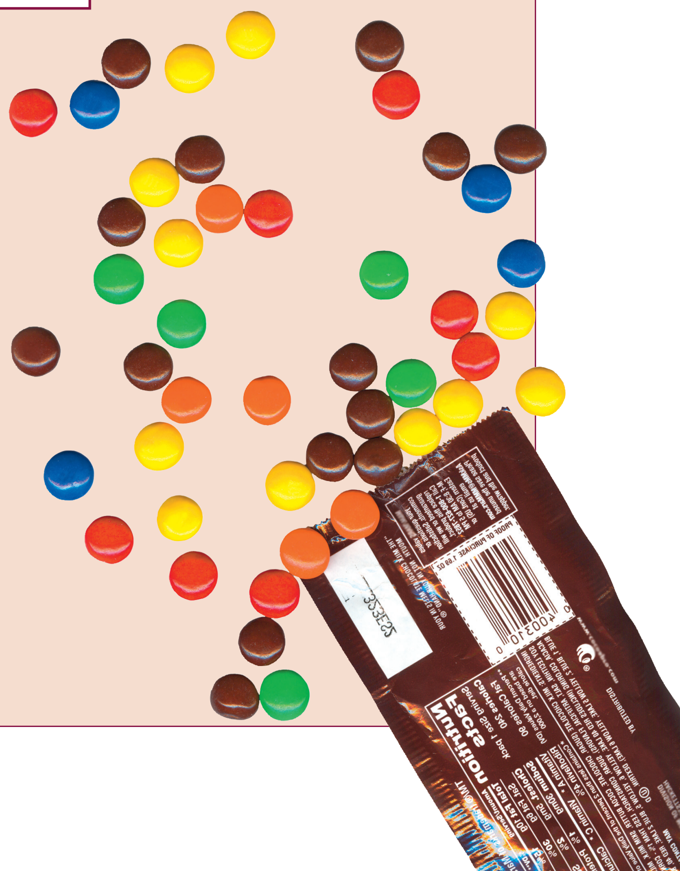
1. Wash your hands before beginning the activity.
2. Do not open your candy pack yet.
3. Estimate the number of each candy color that will be in your candy package.
4. Mass the entire unopened pack and compare the actual mass to the mass listed on the package.
5. Open your pack and count the candies according to color. Record the data on your chart.

Estimated number:	Actual number:
Actual mass (g):	Reported mass (g):
Number of yellow:	
Number of blue:	
Number of brown:	
Number of green:	
Number of red:	
Number of orange:	

6. Record your data on the board with the rest of the class to compare results.
7. Answer the questions.

Questions

1. Was there the same number of candies in each package?
2. What was the smallest number? What was the largest number?
3. Did the mass on the package match the actual mass for every group?
4. What was the lowest mass? What was the highest mass?
5. Do you think the variation in number and mass of candies in each bag to be very significant?
6. How accurate do you think the machinery is that places candies in each package? Would accuracy increase or decrease if humans were to place the candies in the package? Which method would be faster; cheaper; more sanitary?



Activity sheet 2—Do gum sticks hold the same amount of sugar?

Mass sticks of gum, soak them overnight, and then massthe sticks again to see how much sugar dissolved.

Materials (per group)

- five sticks of the same brand of gum in wrappers
- five plastic cups
- same temperature water (warm or hot water will improve rate of dissolving, but remember each cup should be at the same temperature)
- balance

Procedure

1. Mass five sticks of the same brand of gum (leave the wrappers on for cleanliness).
2. Pour enough water into five cups so that each stick of gum will be submerged.
3. Unwrap the gum from the wrappers (save the wrapper) and, at the same time, place the sticks into separate cups of water to soak overnight. Label the cups and wrappers so the samples can be matched later.
4. The next day, place soaked sticks back on the corresponding wrappers and mass each piece. Record your data in the chart.

Brand:	Mass before soaking (g)	Mass after soaking (g)	Difference (g)
1.			
2.			
3.			
4.			
5.			
Average			

5. Compare results as a class and answer the questions.

Questions

1. Was the amount of sugar the same in a given brand of gum when compared to the rest of the class findings?
2. Did amount of sugar vary between different brands of gum? Why?
3. Discuss in your group how you think sugar is placed within a stick of gum.
4. Research the gum manufactoring process on the Internet or by writing to a chewing gum company.

Activity sheet 3—Soft drinks, sugar, and other substances

Determining the amount of sugar and other substances within a specified amount of soft drink.

Materials (per group)

- 150 mL soft drink (50 mL per container)
- balance
- three containers of the same size and shape
- graduated cylinder

Procedure

1. Mass your three empty containers individually.
2. Pour 50 mL of soft drink into each of the three containers (use containers that offer a good deal of surface area to expedite evaporation).
3. Mass each container filled with soft drink.
4. Allow the liquid to evaporate.
5. Once all of the soft drinks are evaporated, mass each container again with the residue of each sample still inside.

Brand:	Mass of empty container (g)	Mass of container and soda (g)	Mass after evaporation (g)	Mass of the leftover substances (g)
1.				
2.				
3.				
Average				

6. Compare data with the rest of the class and answer the questions.

Questions

1. Was the amount of sugar and other substances the same in a given brand of soft drink when compared to the rest of the class findings?
2. Did amount of sugar and other substances vary between different brands of soft drink? Why?
3. Discuss a procedure to test for consistency of carbonation in a soft drink.
4. Research the processes involved for manufactoring various brands of soft drink on the Internet or by writing to a company.