Be a Food Scientist

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Take food out of the kitchen and into the classroom to teach science, mathematics, and more.

By Sharon K. Phillips, Melani W. Duffrin, and Eugene A. Geist

Most of us were told as children to not play with our food. However, when approached in the appropriate manner, food can be a useful teaching tool to develop understandings of science and mathematics concepts.

Think about making something as basic as hard candy. The ingredients are simple—sugar, water, and flavoring—yet the changes that occur are chemically amazing. Drop by drop,small portions of the syrup placed in ice water indicate how saturated the solution is becoming, until a "crack" sound occurs when the candy is at hard-crack stage, its most saturated point!

The whole process is straightforward yet enthralling, as all good science for kids should be. This kind of cooking activity can also provide students oppor-

tunities to observe, describe, calculate, graph, and explain. At least this was our theory, and we decided to try it out on fourth- and fifth-grade students.

We, a talented and gifted instructor, a food and nutrition professor, and an early childhood education professor, developed *Kitchen Wizards: Food Science for Kids*, a series of interactive, standards-based, food-science inquiry lessons that integrated mathematics and science. We created these lessons for the purpose of engaging students in food-science activities while fulfilling national and state standards.

While we created these lessons for students in a talented and gifted program, the activities can be equally successful with children of all abilities. This article shares our experience and will hopefully inspire you to explore the science of food in your classroom.

Math, Science, and Food

After attending a food-science course, the teacher approached educators from the university's food and nutrition and early childhood education departments to collaborate on a project that would address curricular mathematics and science standards. They agreed that food could be an effective way to integrate mathematics and science and engage students in active learning. We knew the food-science inquiry lessons had the potential to help students develop numerous mathematics and science skills (see Figure 1). The skills learned in the activities would also be instantly transferable to the students' own cooking opportunities.

Few children of this age know how fractional math relates to everyday life skills or how food preparation can illustrate scientific processes. In these lessons, numerous mathematics standards would be reinforced, particularly understanding numbers, meanings, and computations, along with understanding of measurable attributes and appropriate techniques, tools, and formulas to determine measurements (NCTM 2000). Other mathematics concepts included data analysis, reasoning, communication, connections, and representation.

The lessons also fulfilled many of the *National Science Education Standards* (NRC 1996), particularly "unifying concepts and process in science" and "science as inquiry."

Each cooking lab was structured as if it were a scientific exploration. Data-gathering techniques, note-taking, hypothesizing, problem solving, and further extension activities were facilitated with a view to providing students with a complete introduction to food as science and to scientific processes. Young researchers had to hypothesize outcomes, follow structured processes, note observations, conjecture causes and effects, and provide evidence for conclusions.

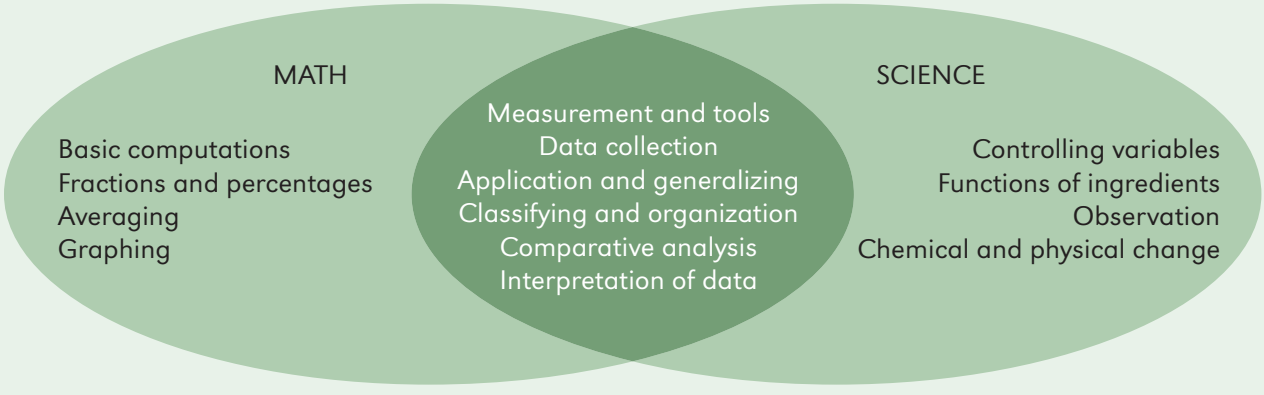
The Necessary Ingredients

Two fourth-grade classes of 10 students each and two fifth-grade classes of 10 students each participated in 14 weeks of food science activities. Eight of the 14 weeks were dedicated specifically to food science, and the remaining six weeks were dedicated to consumer sciences. As part of their resource program, the students met for one two-and-a-half-hour period each week.

Parents and students were provided with a handout previewing the 14 weeks of lessons (see Figure 2, page 26). At the beginning of the program, students were instructed on food safety and reminded of proper food-handling procedures throughout each lesson. The im-

Figure 1.

Math and science skills addressed through food-science inquiries.



Math and science skill development includes but is not limited to the skills listed above. Food-science inquiry lessons implemented in this project emphasized the development of some skills more than others.

Figure 2.

"Kitchen Wizards: Food Science for Kids" handout.

This unit is a 14-week adventure for fourth- and fifth-grade students into the world of food preparation, cooking chemistry, and consumer science. Students will learn measuring basics and the chemical reasons why foods need to be prepared and cooked the way they do. Exciting labs in vegetable, fruit, and egg cookery teach concepts about acids and bases, fats and emulsifiers, and the role of carbohydrates in food. Students will practice scientific processes that require observational research to make predictions and design sound measurable experimentation. Student-created products will introduce ideas about product testing and marketing. **Please notify the teacher of any dietary restrictions or food allergies that your child might have.*

CAUTION

Food-Science Inquiry Lessons

Week One: Weighing In! Students will learn three concepts: the importance of using appropriate measuring tools; the differences between packing, leveling, and sifting; and two ways that fats can be measured.
Skill development: Basic computations, fractions, averaging, measurement, and data collection.

Week Two: Application, Let the Chips Fall! Using measuring concepts learned last week, students will make chocolate chip cookies and taste test the results.
Skill development: Measuring, controlling variables, physical change, and comparative analysis.

Week Three: Hard Candy, Easy Recipe! Observing and noting temperature changes in hard candy sugar mixture through four different cooking states (thread, soft ball, hard ball, and soft cracked stages).
Skill development: Measuring, data collection, observation, physical change, and classifying.

Week Four: Fruit Follies. Using the chemistry of acids and bases to manipulate the browning processes in fresh apples and bananas and making taste test comparisons between canned, fresh, and frozen fruits.
Skills development: Comparative analysis, controlling variables, observation, chemical and physical change, graphing, and interpretation of data.

Week Five: Apple Analysis. Using rubric-style evaluations to compare a variety of apples, both fresh and cooked, in apple crisp.
Skill development: Measurement, data collection, classifying and organization, comparative analysis, interpretation of data, observation, and physical change.

Week Six: Scientific Salad. Comparing fresh, frozen, and canned carrots; observing the effects of broccoli boiled in plain water and in solutions of baking soda and cream of tartar and water.
Skill development: Comparative analysis, observation, chemical and physical change, and functions of ingredients

Week Seven: Good Eggs Fry Hard. Discovering effects of acids and bases on poached eggs; Venn diagramming real and substitute egg dishes.
Skill development: Data collection, application and generalizing, comparative analysis, interpretation of data, observation, and chemical and physical change.

Consumer-Science Lessons

Week Eight: Cola Wars. Determine the amount of sugar needed to attract consumers to a cola product. Using ingredients provided, create and taste test designer colas and name the product.
Skill development: Measurement, controlling variables, observation, and basic computation.

Week Nine: Mad Marketing. Surveying magazines for persuasive language and marketing strategies that could be used to sell a designer cola, designing packaging, and performing a jingle or commercial for a designer cola.

Skill development: Data collection, application and generalizing, comparative analysis, and interpretation of data.

Week Ten: Toothpaste Testing. Following test processes to compare the effectiveness of several aspects of three brands of toothpaste—foam volume, taste, and cleaning strength.
Skill development: Comparative analysis, controlling variables, graphing, and interpretation of data.

Week Eleven: Original Toothpaste Recipes. Selecting predicted amounts of glycerin, soap, bicarbonate, and flavoring to make the best tasting and most effective toothpaste.
Skill development: Basic computations, controlling variables, functions of ingredients, observation, and application and generalization.

Week Twelve: Super Cereal Consumers Product Lab. Using inquiry processes (i.e., questioning, prediction, experimentation, and analysis) to test various cereals for class-determined rubric characteristics using student-designed tests; applying of this process to another product of their choosing. Plus cereal box math!
Skill development: Basic computations, fractions and percentages, data collection, application and generalizing, classifying and organization, and comparative analysis.

Week Thirteen: Battle of the Ads! Designing tests that would provide evidence to support or refute product claims.
Skill development: Interpretation of data and observation.

Week Fourteen: Students' Choice. 1) Continued Kitchen Science: Use classroom resources to choose other kitchen chemistry topics to design your own study of a procedure or food, 2) Historical, Hysterical Recipes: Use antique cookbooks in the classroom collection to research a specific topic (cakes, puddings, cookies, pies) and demonstrate several recipes. Design class survey forms and conduct taste tests for data collection; 3) Mad Muffin Making: Research what each ingredient does in a muffin recipe and design your own creation using what you have learned.
Skill development: This self-directed learning opportunity develops various math and science skills as well as reading, writing, and others. The skills depend on the direction that the student takes with the project.

portance of washing hands for the appropriate amount of time was stressed, and students were required to keep hair pulled back and hands away from faces and clothing during food preparation.

University student volunteers (food and nutrition and early childhood education majors) assisted with the lessons and conducted classroom observations. Their observations provided us with useful information about the logistics of implementing interdisciplinary science lessons involving food in the classroom (see Figure 3, page 28).

The volunteers were crucial partners in the facilitation of each lab. Instances in which food was prepared over hot plates (hard candy) or through baking or boiling, or that required use of knives, made the presence of assistants important for safety. Although the teacher had presented cooking labs in the past without such assistance, these more complicated labs warranted closer monitoring of students.

Students also enjoyed interacting with the college students. Time was allotted for students to ask the college students questions about their experiences to encourage interest in higher education and food-science careers.

Cooks in the Classroom

Each lab in our 14-week series involved measurement and various overlapping mathematics and science skills. Debriefing and evaluating the day's experiences allowed time for incorporating real-life applications.

One way we integrated mathematics was to continually introduce and apply fractions. For example, after students mastered one-half, one-fourth, or one whole, they would be required to adapt and complete more complicated measurement assignments—created by the removal of all but one measuring cup or spoon.

In our first week, students learned the importance of using proper measuring techniques and tools (see NSTA Connection). Students weighed and compared the differences (in grams) between two cups of brown sugar (packed and not packed) and between two cups of flour (sifted and not sifted).

Then, students theorized how the different measuring methods affect recipes, asking, for example, "What would adding unpacked brown sugar instead of packed sugar do to a cookie recipe?" and "If you wanted to create a cake that was dry, coarse, and cracked, should you use sifted or unsifted flour?" These activities gave the students ample opportunity to collect data and make generalizations about their results.

We also compared weight and volume by measuring one-half cup of shortening in a measuring cup and then measuring that same amount through displacement in water.

Figure 3.

Tips for preparing for food-science lessons.

- Inform parents of classroom activities and obtain consent.
- Teach the students about food safety and safe food handling and provide reminders.
- Make sure that student attire is appropriate for the lesson (closed-toe shoes, long pants, hair restraint, and clean clothing). Consider a lab coat or protective garment for the children's clothes.
- Inform students of the rules and enforce the rules. Ensure adequate supervision for lessons that use heat applications.
- Avoid using glass equipment.
- Expect messes (spills, drops, etc.) and be prepared with cleaning supplies.
- Acknowledge and respect students' food preferences and culture.
- Have fun watching your students discover math and science while experimenting with food!

In a later lab experience, students conducted a comparative analysis of fresh, frozen, and canned carrots (see NSTA Connection). First, fresh carrots were sampled and evaluated for appearance, texture, and flavor. Next, samples of uncooked frozen and canned carrots were sampled and evaluated and the data was recorded. Finally, all three samples were cooked, sampled, and evaluated. The student compared the uncooked and cooked products using the rubrics "color closest to fresh," "texture," and "flavor closest to fresh" and graphed their results.

They also observed the scientific process of leaching—indicated through color transfer as the vegetables lost cell contents, known as *flavonoids*, to the water. We explained that those compounds were what gave the vegetables their nutrients and color. Thus, the brighter the colored water, the more nutrients lost in the cooking or canning process.

Students discovered that the heating process needed for commercial canning resulted in loss of the most flavonoids (based on their comparisons of water color after cooking) and, based on their observations that frozen produce retained freshness better than canning. To conclude our lab, students debated the merits of each food preservation (canning and freezing) method and how they compared with fresh.

Next, students observed physical and chemical changes by comparing fresh broccoli boiled in different solutions: plain water; water and baking soda; and water and cream of tartar. Students observed how heat affects cell structure, resulting in mushy, overcooked vegetables. The children were also surprised to find the cream of tartar turned the cooked broccoli gray and wanted to know, "What happened to the color?" The fact that cooking the broccoli in cream of tartar produced darker cooking water seemed to indicate that the color—and nutrients—were once again moving into the water!

In their "Scientific Salad" exploration, students were heavily engaged, motivated by real scientific inquiry and open-ended exploration, yet still experienced the kinds of processes that meet national standards: research notation, problem solving, record keeping, graphing and reading graphs, hypothesizing, and practicing science skills.

Tasty Tests

Assessment was ongoing throughout the food-science investigations, but we also planned for a final project assignment as a culminating event for the program. Students would demonstrate their understanding with a recipe research project and presentation.

Teams of students were assigned a specific recipe category, such as no-bake cookies, types of pizza, filled cookies, refrigerator pies, and cakes, and were instructed to research the characteristic cooking methods (discussed in the general cooking or baking sections of cookbooks) and common ingredients found in at least seven examples of that category.

Working in pairs, students prepared their recipe (enough to offer samples to the rest of their class for review). Because our class labs had already introduced terms like *blend, fold, beat, separate, blanch, whip,* and *cut-in,* students were immediately able to put their newly learned culinary skills to work. Each team was required to present a poster that described their category, the common elements in the seven recipes, and the alterations and substitutions that were possible within the specific recipe they tried.

After the class taste tested each product, a critique often spawned ideas for modifications that could be applied to the recipe. Discussion ensued that eventually led many young researchers to design a new product based on a few simple alterations or substitutions in the recipe.

At the close of our program students were observed for evaluation as they presented their colorful posters to seven classrooms of students and their teachers who walked through our "product fair."

Connecting to the Standards

This article relates to the following *National Science Education Standards* (NRC 1996):

Content Standards

Grades K–12

Unifying Concepts and Process in Science

- Evidence, models, and explanation
- Constancy, change, and measurement
- Form and function

Standard A: Science as Inquiry

- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

This article relates to the following *Principles and Standards for School Mathematics* (NCTM 2000):

Grades PreK–12

Measurement

- Understand measurable attributes of objects and the units, systems, and processes of measurement
- Apply appropriate techniques, tools, and formulas to determine measurements

Data Analysis and Probability

- Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them
- Develop and evaluate inferences and predictions that are based on data

Connections

- Recognize and apply mathematics in contexts outside of mathematics

A Recipe for Success

Overall, the experience was positive for everyone involved. The children were actively engaged in the learning process; they learned about food and nutrition; they became more educated "consumers"; and they developed mathematics and science skills.

Many students wanted to take recipes home or check out cookbooks. Student comments suggested that their academic experiences were reinforced because food was a tool that enabled them to interact academically with their families, friends, and teachers.

The college student volunteers and classroom observers benefited as well. Through the program, these teacher candidates furthered their knowledge of food, mathematics, and science *and* gained experience working with fourth- and fifth-grade students. In addition, they were mentored by classroom teachers and given opportunities to discuss and independently study the process of curriculum development.

We teachers thoroughly enjoyed the activity and excitement it brought to our students. For us, the learning outcomes were well worth the investment of time in developing the activities and university partnership.

In fact, the program was so successful it led us to develop the FoodMASTER Initiative (Food, Math, and Science Teaching Enhancement Resource)—a compilation of programs aimed at enhancing food, mathematics, and science education for individuals of all ages and backgrounds. This initiative has inspired several partnerships between K–12 teachers and community professionals and furthered strengthened the collaborative relationship between the early childhood education and the food and nutrition departments at the university.

And, there's no end in sight. With new ideas cropping up all the time, we've just begun to explore the possibilities of how food can be used in the context of learning. Whether studying science, learning about health and nutrition, developing mathematics skills, or forging new relationships in the community, something is definitely cooking! ■

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Resources

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Internet

FoodMASTER

www.hcs.ohiou.edu/foodmaster

NSTA Connection

View the measuring and vegetable comparison worksheets online by clicking on this article at *www.nsta.org/elementaryschool.*