Curriculum Units by Fellows of the Yale-New Haven Teachers Institute
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Young Engineers: Understanding Engineering through Cooking

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Children formulate goals and aspirations for themselves based on the successful people they see in their own community, and in the community I teach in, the students are limited in the types of people they have experiences with. If I asked the question, "What do you want to be when you grow up," many of the students would reply: doctor, teacher, or police officer, because these are the careers that they recognize and have experiences with. Although these careers are respectable ones to aspire to, it limits children who have intelligences in other areas. One of my goals is to expose students to other types of careers in industry while capitalizing on their strengths in an engaging hands-on unit.

When thinking about capitalizing on students' strengths, it is helpful to consider Howard Gardner's research in the area of intelligence. Gardner identifies seven different intelligences. The two that are most recognized in traditional educational settings are the logical mathematical intelligence, and the linguistic intelligence.(1) Students, who excel in school, usually excel in these areas because they are the intelligences we most value in traditional schools. In this unit, I have incorporated learning experiences for the logical-mathematical intelligence, the spatial intelligence, and the bodily-kinesthetic intelligence. These learning experiences will act as a bridge to literacy. This will provide students with a variety of intelligence aptitudes with opportunities for success. It will also build valuable skills and competencies.

What is Engineering?

"Engineers are team players who improve products, processes, and services."(2) Deeply rooted in the disciplines of science and mathematics, engineering is problem solving. This is vague, but engineers are needed for a broad range of highly specific careers. The U.S. Department of Labor identifies 25 engineering areas of specialization with over 80 subdivisions, but there are only six areas of engineering that comprise a major part of the profession. These areas are chemical engineering, civil engineering, electrical and electronics engineering, industrial engineering, materials science engineering, and mechanical engineering.(2)

Engineers today and throughout history have seen problems, or needs in the society in which they lived, and met these issues with products, processes, or services. Engineers use scientific research, and apply it to solve a problem or fulfill a demand for a product or service.

The need for specific types of engineering is reflective of society. For example, Imhotep, one of the first known engineers, built the stepped pyramid in Egypt around 2550 B.C. Early engineering was in construction of monuments and structures to serve functional purposes as well as religious purposes for the time period. This development of the craft of engineering by the Egyptians, Persians, Medieval Europeans, and Asians of the ancient Mongol empire lead to beautifully crafted ancient cities. (2)

Civil engineering developed in the mid 1700s with the opening of the first school of engineering, the National School of Bridges and Highways in France in 1747. (2) Civil engineers were needed at this time, and still today, to plan cities, build highways, and create sanitation and water systems. Mechanical engineering began during the industrial revolution, when there was a need for machines to make the mass production of products more efficient. Currently, mechanical engineers create new machines, and improve the efficiency of existing machines. For example, a mechanical engineer might work for a company to improve the efficiency of heating and cooling systems. Since engineering is reflective of society's needs, it is not surprising that in our current society the largest branch of engineering is electrical and electronics engineering. (2) Electrical and electronic engineers, work to meet the needs of companies and consumers. An electrical engineer might design computers, robots, or stereo systems. In the future engineering will continue to meet the demands of society. It is foreseeable that engineering will expand to nanotechnology and sensors. (2)

What is Industrial Engineering?

Industrial engineering is one of the top four branches of engineering. (2) Industrial engineers are problem-solvers and leaders. These are two qualities that we are constantly striving to develop in our young students, which is one of the reasons I chose industrial engineering as the central focus of this unit. "Industrial engineering involves design, organization, and implementation of integrated systems using people, materials, and equipment." (2) Simply put, industrial engineers study the systems of a company or organization and make decisions about how the systems could be more efficient and more effective.

One of the most famous industrial engineers is Henry Ford, well known for his work in the automotive industry. Henry Ford optimized the assembly process of building automobiles. With the ability to produce cars quickly and efficiently, it became more affordable for people to own cars. This changed society as we know it. Henry Ford was granted time at work while employed by the Edison Illumination Company to spend exploring his own personal interests. His independent work lead to the development of the quadricycle, a self propelled vehicle, and a predecessor to the automobile.(3) In 1903, Henry Ford was the vice-president and chief engineer of Ford Motor Company, where he helped to develop the Model T. This car was reliable and not too costly for the customer. Because of the great demand for the Model T, Ford had to open a new factory in 1918. He was instrumental in introducing the moving assembly line. The Model T would move on a conveyor belt, and each person on the line would be responsible for adding another part to the vehicle. This made the manufacturing of automobiles more efficient and cost effective so that more people cold afford, the Model T.(6) More stories of famous engineers can be found at the following website: http://www.engineeringk12.org/getinvolved/ASEE_Workshop_On_K12_Engineering_Education/Past_ASEE_K12_Workshops/documents_2006/StandardsBasedLearningmanual.pdf More information and pictures of Henry Ford and his inventions can be found at http://www.hfmgv.org/EXHIBITS/HF/

Within industrial engineering, the focus for this unit is process engineering. Process engineers develop processes to make products. They research and develop the most efficient methods, and monitor the effectiveness of the process. This branch of engineering, although specific, encompasses many different products from airplanes to electronics, and in our case - chocolate chip cookies.

Practical Applications of Engineering in the Job Force

Industrial engineers can be employed in any number of careers because of its broad base of applications. In hospitals, industrial engineers may design complex systems for admitting patients in an organized and efficient way. Industrial engineers in a medical device company may design and monitor quality control tests to be sure the products are safe, effective, and meet the needs of the consumers. An industrial engineer, who works for an amusement park, may design or improve the park layout so that people can move quickly through lines. (2) Industrial engineers are flexible. One industrial engineer's day-to-day job tasks may look extremely different from another's, but the one thing they all have in common is creating efficiency in industry.

There are many different paths that an industrial engineer can embark on in his or her career. An industrial engineer may choose one of two career tracks, the technical track or the managerial track. The technical track includes careers in which an engineer applies his or her expertise from an engineering background. The other tract utilizes more interpersonal management skills as they relate to engineering. (2)

Jobs on the technical track include research and development (R&D), production, and technical professional services. Research and development is a career that is important in our society because it keeps our country's corporations and universities competitive. Industrial engineers in research and development solve problems and create new products. (2) In industry, production engineers are involved in every aspect of taking a product from concept to launch. Technical and professional service engineers do consulting and are often project managers. (2) Jobs on the technical track will be addressed in this unit, through research, development, and optimization of the cookie making process.

On the management track, engineers can work in marketing and sales, information systems processing, account financing, and administration. Although knowledge of engineering is necessary on this track, engineering skills need to be balanced with a sense of business and interpersonal managerial skills. Jobs on the management track will be addressed in this unit through the culminating project, which is to run a mock business in cookie sales.

In industry, many of Gardner's intelligences are utilized. Engineers must be able to plan and have a vision of the finished product, or effective process. This taps into the logical mathematical intelligence. The logical mathematical intelligence is "The capacity to analyze problems logically, carry out mathematical operations, and investigate issues scientifically." 1 Depending on the product, or process, an engineer may need to use his or her spatial intelligence to mentally plan out a physical design before drafting and creating it. The spatial intelligence is "The potential to recognize and use the patterns of wide space and more confined areas." 1 This may be the case in city planning, or offices designed for efficiency. Manufacturing personnel rely heavily on their bodily kinesthetic intelligence to work with their hands and create a product. The bodily kinesthetic intelligence is, "The potential of using one's whole body or parts of the body to solve problems. It is the ability to use mental abilities to coordinate bodily movements." 1 Engineers on the managerial track also need a strong interpersonal intelligence to be able to manage people effectively. This intelligence is defined as "The capacity to understand the intentions, motivations and desires of other people." (1)

Why Teach Second Graders About Industrial Engineering?

In addition to the need to expose children to a variety of careers throughout their school experience, industrial engineering demands character traits and skills that teachers are always trying to develop in students. Industrial engineers are problem-solvers, data-analyzers, decision-makers leaders, logical-thinkers, researchers, and risk-takers. Industrial engineers look at the big picture and utilize mathematics and research skills to develop the quality of a product or the efficiency of a process.

Throughout this unit, children will be asked to think. So often children are accustomed to there being one right answer in school, but in the work force, and adult life in general, it is not always the case. Often, there may be a variety of processes that will create a product, and it is a question of developing the most efficient one. Other times, there may be a variety of solutions that will solve a problem, and we have to choose the one that makes the most sense at the time. Hardly ever is there a situation in which there is only one right way. Because of this, we must develop these critical thinking and problem-solving skills in our students.

Why Chocolate Chip Cookies?

Why chocolate chip cookies? Why not chocolate chip cookies? Everyone loves chocolate chip cookies, and it is a challenge to find anything more engaging to a second grader. Very few things can hold a second graders attention like a chocolate chip cookie. Another thing second graders love - a challenge. Challenging a class to engineer the world's greatest chocolate chip cookie is conceivably the most exciting endeavor a second grader can undertake.

More importantly, the quality of chocolate chip cookies can be evaluated on a larger scale beyond taste. In this unit, it will be important for children to collect and analyze data. I chose chocolate chip cookies because in addition to taste, there is variability in the texture, pliability, shape, color, and number and type of chips. Each of these cookie traits, contribute to quality, unlike some other foods in which taste is the only factor in quality. Because of these variables of quality and personal preference, students will be able to evaluate and engineer a cookie based on a number of cookie traits beyond just taste. If an oven is not available, alternatively, pudding can be used as the central focus for this unit because of its similar evaluative qualities.

Unit Overview

Joseph Renzuli proposes an educational enrichment triad model, which suggests exposing children (specifically gifted children) to different types of enrichment. This unit will begin with a type one enrichment activity or a general exploratory activity. These type one exploratory activities are meant to expose students to a wide variety of topics that they otherwise would not generally be exposed to. (4) This includes guest speakers and exposure to different careers. I would suggest either bringing in an industrial engineer to speak to the children about his or her job, or bringing in a variety of engineers to speak to the children. Being exposed to real live engineers who are able to answer their questions will make this unit more real for the students, and give them something to aspire to. To connect with an engineer, and for information about teaching young students about engineering as well as partnerships with professional engineering organizations, visit the following website developed by the American Society for Engineering Education (ASEE): http://www.engineeringk12.org/, or contact your local college or university.

A chart can be started on the first day of this unit to list and develop the student's understanding of what an engineer does. The chart can be headed Our Understanding of Engineers and the students can add to it and change it after each lesson to reflect their understanding of engineering. Including one or two days of general engineering activities will give students a general idea for engineering as a career based in problem solving. These engineering activities can be selected from Janice VanCleave's book, Engineering for Every Kid: Easy Activities that Make Learning Science Fun, (5) or the website http://www.engineeringk12.org/.

This project can be introduced to the students by challenging them to engineer the world's best chocolate chip cookie. The first order of business is creating specifications to identify markers of a quality chocolate chip cookie. In order for students to create the best chocolate chip cookie, they must first determine what makes a quality chocolate chip cookie. In engineering, this is the job of the research and development (R&D) engineers, marketing personnel or others, depending on the company. Setting the quality specifications for chocolate chip cookies can be done in a series of three lessons.

During these first three lessons, the students will lay the foundation for the rest of the unit. In the first lesson, they will create a rubric for assessing chocolate chip cookies. (see lesson 1) A rubric is a set of standards developed for assessment (see example rubric in appendix b). It is beneficial to expose students to rubrics because their school work is often assessed using rubrics. In the second lesson, the students will learn to ask good questions and they will talk to other teachers and students in order to collect data about what other people want in a chocolate chip cookie. This is called gathering the voice of the customer, or customer requirements. Then they will return to their original rubric and revise it to reflect the voice of the customer.

After the students have determined what people want in a cookie, they can begin research and development. Since most engineers do not create anything completely from scratch, the students will be reading and evaluating various existing cookie recipes. The website http://allrecipes.com/ or a similar recipe share website can be used to obtain these recipes. The students will experiment to determine what effect individual ingredients have on the finished product. After conducting these experiments the students will use their findings to guide a discussion about which ingredients in what amounts produce the desired results based on the specifications created earlier in the unit. (see lesson 3)

In the next lesson, after groups of students review and discuss their notes together, they will be able to craft a recipe using the experimental recipes that produced desired results, and their own ideas about the ingredients. After the cookies have been baked, the students will work in their groups to do a blind taste test in order to evaluate each batch of cookies based on the quality specification rubric that they developed as a class.

The winning cookie recipe will be posted on the internet using the site http://allrecipes.com/ or a similar recipe site, and the children can periodically check the ratings and reviews of the product. If time allows, the students can even revise the recipe again based on reviews from the website. After the children decide on the best cookie recipe, they will write a report that includes a write up of the recipe and a narrative explanation of the entire process.

The winning cookie recipe will then be used in the culminating event, a mock corporation/cookie sale. The students will take on different roles in industry. Sales, marketing, quality control and production teams will be put together, and the students will have a cookie sale. Marketing will be responsible for developing posters prior to the cookie sale, soliciting consumer feedback after the cookie sale, and checking the recipe website periodically to check for and read reviews of the recipe. Production will follow the recipe to bake the cookies. Quality control will test samples for quality and consistency using the cookie rubric from the first lesson. The sales team will sell the cookies.

Scope and Sequence

Day 1: Guest speaker on engineering (described in detail above).
Day 2: Engineering activities- Students share back at the end of the activities about what an engineer does (described in detail above).
Day 3: Setting quality specifications for a chocolate-chip cookie (see lesson 1).
Day 4: Revising quality specifications - considering the voice of customer: asking the right questions. The students will plan survey questions to get the desired information from the cookie consumers.
Day 5: Revising quality specifications - considering voice of customer (see lesson 2)
Day 6: Research and development- (see lesson 3)
Day 7: The students will use what they have learned from previous lessons and experiments to evaluate different recipes and determining the effects of different ingredients.
Day 8: Research and development - Groups will review their notes and develop a recipe based on their research findings.
Day 9: Groups will test their newly developed recipes under the supervision of the teacher.
Day 10: The groups from day 9 will assess the product that they created using the rubric that was created and revised by the class.
Day 11: Continuous improvement and next generation of product - students will be allowed to experiment with additives to the recipe i.e. double chocolate chips, vanilla chips, chocolate chunks, marshmallows etc.
Day 12: A few students will be responsible on this day for typing and posting the qualifying recipe on the website http://www.allrecepes.com or a similar recipe share site.
Mock corporation and cookie sale: This part of the unit is optional and can be used as an

extension if students are engaged, and if time allows.
Day 13: Production: groups of students will collaborate and follow the recipe to produce the winning recipe from the unit.
Day 14: Quality control: groups of students will test one cookie from each groups batch to be sure that all batches meet the quality standards set forth in the rubric.
Day 15: Sales - students may be allowed to sell the cookies during lunch or after school if possible.

Conclusion: Final paper explaining engineering as a job, and narrative writing explaining the cookie project (see appendix b).

Lessons

Lesson 1: What makes a quality cookie?

Focus and Objectives

Students will think critically to answer the question 'What qualities make a good chocolate chip cookie?' Students will discuss and evaluate quality of different brands and types of cookies. Students will be able to create quality specifications in the form of a rubric.

Materials

3-4 different kinds of chocolate chip cookies (enough for each child to have one of each type of cookie), blank rubric form (see Chocolate Chip Cookie Rubric in Appendix b)

Procedure

1. Pose the question: "What qualities make a good chocolate chip cookie? Ask the students to discuss this with a partner for a few seconds and share back to the group in a think pair share format.
2. Introduce the word 'specifications' and tell students that in order to create the world's best chocolate chip cookie, we first must decide what the world's best chocolate chip cookie will be like, so we need to create specifications.
3. Give the students the different types of chocolate chip cookies without showing them the brand or type and let them first discuss what is similar and different about the cookies and record it in their observation notes.
4. After the children have had a chance to record and review their notes, tell them that we have to decide which of these qualities make the best chocolate chip cookies. Use the blank rubric format on an overhead projector, or copied onto chart paper and work as a class to make decisions about quality cookies.
5. Fill in the rubric with the quality standards that the students agree on. (see the sample rubric as an example appendix b).
6. As you are recording on the model rubric, have each student copy the information into a blank rubric.
7. Students will work in groups and use the rubrics that they created to rate each cookie.

Teacher dialogue example: "Texture means how the cookie feels in your mouth. Take a bite of the first type of cookie. Is it spongy like cake, or gooey like a brownie? "Notice the shape and size of the cookies. Is it round, or oval, or kind of lumpy? Measure the size across the cookie with your ruler and include the measurements in your notes."

"Break apart one of each type of cookie at a time and count the number of chips that were in the cookie. Also notice the kind of chips in the cookie. Are they small chips, big chips, or chocolate chunks?"

Conclusion

Have each group present their findings. Allow them to discuss the ratings they gave to each cookie, and why their ratings may be different from another group's rating.

Lesson 2: Revising Quality specifications and Considering the Voice of the Customer

Objectives

The students will be able to analyze data collected from a survey, and apply the data to revise the standards.

Materials

Questions created from the previous lesson (see scope and sequence), note taking paper, clip boards, pencils.

Procedure

1. Students will use the questions they came up with during the questioning lesson, and survey other teachers and students in the building to obtain their opinions about a quality chocolate chip cookie.
2. Students will chart their data to reflect the customers' preferences for size, shape, number of chips, texture, and taste of chocolate chip cookies.
3. The students will work in groups to revise the rubric from the first lesson so that it reflects the voice of the customer.

Conclusion

Have the students reflect in writing about why it is important to include the voice of the customer in the quality specifications.

Lesson 3: Research and Development

**Note: this lesson will take place over a span of several days

Objectives

Students will be able to utilize the scientific method in order to draw conclusions about a recipe.

Materials

A chocolate chip cookie recipe from http://www.allrecipes.com or a similar recipe sharing website, cookie ingredients in amounts determined by your chosen recipe (enough for each group to make a batch), measuring cups, spoons, cookie trays, spatulas, cooling trays, and access to an oven.

Procedure

1. Prior to the lesson, adjust the recipe so there are six different versions: one recipe with the called for amount of flour, and one with double flour; one recipe with butter, one with margarine instead of butter; one recipe using brown sugar, and one using white sugar. Also, post the steps in the scientific method on chart paper or an overhead projector as follows:

Question: How can we create a recipe for the best chocolate chip cookies?
Hypothesis: If we do experiments to see what effect the ingredients of the recipe have on the finished product, we can use this information to write the best recipe.
Experiment:

1. Put together six teams of engineers.
2. Use the diagram to see which recipe you should test.
3. Test your recipe in your group.
4. See how your recipe meets the quality standards using the rubric.
5. Discuss your findings with the other teams.

Results:

Group 1	Group 2
Group 3	Group 4
Group 5	Group 6

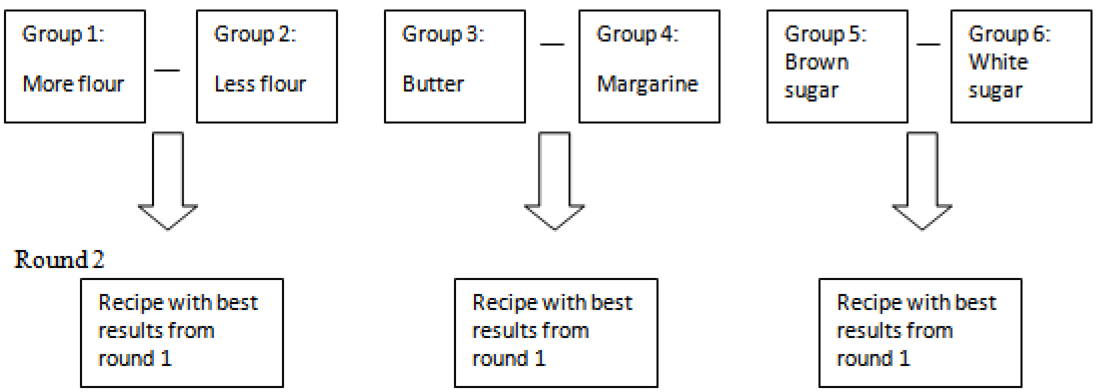
Conclusion:

Groups 1 & 2:
Groups 3 & 4:
Groups 5&6

**Note: Students will be filling in the blanks on the scientific method chart as they complete the experiments.

2. Show the students the scientific method chart and explain the question and hypothesis.
3. Divide students into 6 groups.
   Use the following diagram to organize students into teams to evaluate different ingredients.
4. Teams will consist of two groups that will work together to compare and contrast different recipes with one varied ingredient.

Round 1



**note: The round 2 cookies do not have to be baked. The cookie recipes in round two are the more successful recipes from each team in round 1. The round two recipes will be discussed and used for the mock corporation/cookie sale.

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Appendix A: Standards

The following standards were taken from the Connecticut State Department of Education Mathematics Curriculum Framework Matrix

4.2 Analyze data sets to form hypotheses and make predictions.

3.3 Develop and apply units, systems, formulas and appropriate tools to estimate and measure.

The following curriculum standard was taken from the Connecticut State Department of Education Language Arts Curriculum Framework Matrix.

3.2 Students prepare, publish and/or present work appropriate to audience, purpose and task (the second grade substandard states that students will) research information from multiple sources for a specific purpose.

This unit meets Connecticut State Department of Education Mathematical Curriculum standards 4.3 and 3.3. Throughout this unit, students are asked to make predictions and hypothesis and to discuss expected outcomes of experiments involving cooking, and then test those predictions through experimentation. Students will also be expected to use data to drive their decision making. Students will use standard units of measure to follow a procedure in order to bake cookies. This unit also addresses Language Arts standard 3.2 through the final paper for the project, and the readings and experimental research throughout the unit.

Appendix B Worksheets and Samples

Worksheet 1

Project Goals and Requirements

Goals:

I will learn about engineering.

I will think.

I will talk.

I will collect data.

I will learn to take notes.

Requirements:

I will keep my science notebook neat and take good notes.

I will collect data from my experiments and keep track of it in my science notebook.

I will write a paper clearly describing the project I did and the things that I learned.

I will write a recipe.

I will be able to read and follow a recipe.

Worksheet 2

Chocolate Chip Cookie Rubric

Names:______________________________

Date:______________________________

Cookie #__________

	1	2	3
Texture			
Taste			
Number of Chips			
Pliability			
Shape and Size of Cookie			

Total score:__________

Worksheet 3

Chocolate Chip Cookie Rubric Example

This is an example that I created with my class on chart paper, and then typed up as an exaple. It will give you an idea for what to expect in terms of student responses.

Cookie: # 1 Total score: 11

	1	2	3
Texture	The cookie may be stale. It is not crisp or chewy. The chocolate chips are not gooey.	The cookie is crispy and the chocolate chips are gooey.	The cookie is soft and the chocolate chips are gooey.
Taste	The cookie is not salty or sweet, and it might be stale.	The cookie is salty or sweet.	The cookie is salty and sweet.
Number of Chips	Some bites do not have chocolate chips in them.	All bites have at least one chocolate chip in them.	All bites have more than one chocolate chip in them.
Shape and Size of Cookie	The cookie is not round, and is less than 2 inches across.	The cookie is round or more than 2 inches across.	The cookie is round and more than two inches across.

Final Score______

My comments:

Worksheet 4

Final paper rubric

	1	2	3
Explanation of what an engineer does	My paper gives no examples of what an engineer does.	My paper gives one or two examples of what an engineer does.	My paper gives three or more clear examples of what an engineer does
Narrative story about what I did to be an engineer during this unit.	I am not clear and give few or no details explaining what I did.	I am clear, but give only a few details about what I did.	I am clear and explain in order what I did during this project.
Recipe	I did not include a recipe in my paper	I did include a recipe in my paper.	The recipe in my paper is clear, and someone else could follow it to make chocolate chip cookies.
Editing	My paper has many misspelled words and missing punctuation and capital letters.	My paper has only a few misspelled words and only a few mistakes in punctuation or capital letters.	My paper has no mistakes in punctuation, spelling, or capital letters.

Final score:__________

My comments:

My teacher's comments:

Notes

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1. Smith, Mary & Gardner, Howard
2. Garner, Geraldine, 2009
3. Carpinelli, John D.; Kimmwl, Howard; and Rockland, Ronald H., 2006
4. Renzuli, Joseph, 1997
5. VanCleave, Janice, 2007
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