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You Belong:
Women in Manufacturing

An Educator's Guide

CAREER PATHWAYS

Connecticut Community Colleges' College of Technology's Regional Center for Next Generation Manufacturing

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Career Pathways
You Belong: Women in Manufacturing

AN EDUCATOR'S GUIDE

The Connecticut College of Technology and its National Science Foundation-funded Regional Center for Next Generation Manufacturing (RCNGM), in collaboration with the Connecticut Business & Industry Association (CBIA), are pleased to present *You Belong: Women in Manufacturing*. This teacher guide and accompanying poster and DVD are designed to enlighten educators as well as young women seeking career direction about the exciting opportunities in today's advanced manufacturing.

The good news is that more than 500,000 manufacturing jobs in America have been created in the last three years.[1] However, the majority of these jobs—over 70%—are being filled by men, even though women comprise more than half of the overall workforce. A combination of misperceptions about the industry, lack of knowledge about what careers are available, and preconceived notions that they might not be physically strong enough or proficient enough in math and science are factors that may be keeping women from pursuing manufacturing careers.

But women should consider these careers now more than ever. With the world's largest manufacturing economy, America and its competitiveness are tied to manufacturing. Manufacturing accounts for 70% of research and development in the nation, creating more innovation than any other economic sector. The National Association of Manufacturers (NAM) estimates that "every $1 in manufactured goods generates an additional $1.48 worth of economic activity [again] more than any other economic sector."

Yet, manufacturers are having difficulty finding and retaining skilled workers. Coupled with the fact that more than half of all manufacturing employees are 45 years or older, manufacturers are facing a serious skilled labor force shortage. By exploring and preparing for careers in manufacturing, women can make a significant positive impact on America's economy. Today's clean, high-tech manufacturing environment offers a wide range of employment opportunities for women. Jobs are rewarding and increasingly dependent on technical, professional, and interpersonal skills as well as a solid foundation in science, math, and English.

This guide, along with the DVD highlighting several women in successful manufacturing careers, is designed to help women understand why they belong in manufacturing. The learning activities in the guide supplement the DVD segments, providing information on jobs in demand, salary data, and educational pathways to manufacturing careers through the Connecticut College of Technology. We encourage you to share this free resource with students, parents, administrators, and colleagues.

Sincerely,

Karen Wosczyna-Birch

Dr. Karen Wosczyna-Birch, Executive Director
Connecticut College of Technology
Regional Center for Next Generation Manufacturing

Judith K. Resnick

Judith K. Resnick
Executive Director
CBIA Education Foundation

[1] *Joint Economic Committee Democratic Staff, Bureau of Labor Statistics, May, 2013*

Career Pathways You Belong: Women in Manufacturing

AN EDUCATOR'S GUIDE

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ANSWER KEY

Meet Today's Women in Manufacturing, p. 16

1. A'arika, 2. Jessica, 3. Laurie, 4. Shelby, 5. Shelley, 6. Myrna

Photos, p. 14-15: Martha Coston, New York Public Library; Helen Augusta Blanchard, American Women: Fifteen Hundred Biographies with over 1,400 Portraits, Frances E. Willard and Mary A. Livermore; Mary Anderson, Birmingham, Ala. Public Library Archives; Lillian Gilbreth, Rutgers University Archive; Hedy Lamarr, Warner Brothers studio publicity; Grace Murray Hopper, U.S. Navy; Stephanie Kwolek, courtesy of DuPont; Bonnie Dunbar, NASA; Elsa Garmire, Thayer School of Engineering at Dartmouth; Marissa Mayer, World Economic Forum

Contents

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This part of the teacher guide introduces you to why women belong in manufacturing. Refer to the DVD Overview.

Part One Women Making an Impact in Manufacturing

History of Women in Manufacturing

Before World War II, the notion of women building airplanes or ships was virtually unheard of. But during the war, that's exactly what they did. While men were overseas, women contributed mightily to the war effort with thousands entering factories to build whatever was needed to sustain America's war machinery and keep America's economy vital. In fact, between 1940 and 1945, the number of women in the labor force increased by 50 percent; in the defense industry alone, women's presence jumped by an overwhelming 400 percent. For women who were already in manufacturing, this employment surge provided new opportunities for upward mobility that had previously been denied them. Despite these strides, however, women still encountered barriers. When men returned from the war they returned to the factories, and women found themselves back at what were considered more "traditional" roles.[2]

The historic wartime jobs transformation, however, proved that women were as capable as men of working in a manufacturing environment. Some would even say this period of American history provided the impetus for the feminist movement in the decades to come.

In the early 1970s, women began to recognize that they had the potential to make a strong contribution both inside and outside of the home. Career opportunities began to open up, this time with greater acceptance in areas traditionally considered male domains. Unlike their mothers, however, the daughters of World War II factory workers didn't consider manufacturing careers, because they believed that many of these jobs were lower-level jobs offering little opportunity for career advancement; that manufacturing was a "man's world," where too much physical strength was required; and that manufacturing's required proficiency in math and technology were beyond their abilities.

[2] *http://historymatters.gmu.edu; documents from the National Archives, Joint Economic Committee, United States Congress, Women in Manufacturing, April 2013*

Women in Manufacturing Today

Since the advent of the women's movement in the 1970s, women have made great strides in achieving equality in the workplace. Today, women in manufacturing have the same opportunities as men—whether it's operating a complex machine, designing a product, or managing the operations of an entire company. Yet between 2010 and 2011, according to a study by the National Women's Law Center, men gained 230,000 jobs in manufacturing while women lost 25,000 jobs. Today, only about 30 percent of Americans who work in manufacturing are women, and 15 percent of students enrolled in manufacturing degree programs are women.[3]

Why is there such disparity between the number of men and women in manufacturing? It could be due to misinformation about what careers are available, general skepticism about the stability of the manufacturing industry, and the perception that manufacturing is still a man's world that requires unattainable physical strength and math proficiency.

A'arika Hawkins, Mechanical Engineer, UTC Aerospace Systems

Another factor that often keeps women from considering careers in manufacturing is lack of confidence. This may be due to minimal exposure to tinkering with machines or performing mechanical tasks while growing up. It may also be due to an aversion to the science, technology, engineering and math (STEM) skills that are often required in manufacturing. Statistics show that female students often lack the confidence that male students have in succeeding in math, a subject critical to advancement in manufacturing. Despite efforts to encourage girls and young women to pursue STEM careers, male students are three times more likely to be interested in STEM majors and careers than female students.[4]

Women can make a critical difference in an industry today that is in dire need of qualified skilled workers. Over the last three years, more than 500,000 manufacturing jobs have been created in the United States.[5] Many manufacturers are also returning some of their foreign operations to America, partly because of rising wages overseas and concerns over quality control. Compounding the shortage of skilled manufacturing workers is the fact that over half of manufacturing workers are over 45, with many of them expected to retire within the next five years. As many as 600,000 manufacturing jobs are now going unfilled.[6]

With the right credentials, women can fill the gap for qualified skilled workers needed by manufacturers today and in the future. The time is right for exploring these opportunities. (Refer to the overview in the DVD regarding stackable credentials)

[3] "Why More Women Aren't in Manufacturing," Industry Market Trends, Sept. 5, 2012; [4] My College Options: STEM Connector, 2012–2013; [5] Joint Economic Committee, Democratic Staff, United States Congress, Women in Manufacturing, April 2013; and Bureau of Labor Statistics; [6] "U.S. Manufacturing Sees Shortage of Skilled Factory Workers," Washington Post, Feb. 19, 2012

Why Women Belong in Manufacturing

Many women have characteristics that are in high demand among manufacturers, including:

- **NEGOTIATORS/CONSENSUS BUILDERS:** Good relationships are vital in the workplace. Women, in the interest of consensus building, often will negotiate the best possible solution to a problem that will have a positive outcome for all involved.
- **DETAIL-ORIENTED:** Many women are detail-oriented, which is an important skill in today's manufacturing environment.
- **TEAM PLAYERS:** Women are often adept at collaborating and bringing teams together, another asset in manufacturing environments.
- **GLOBAL THINKERS:** Women can be particularly adept at seeing the bigger picture which makes it easier for them to find solutions to problems.
- **MULTI-TASKING:** Most women are used to playing multiple roles, such as in balancing family and work responsibilities. Multi-tasking is a skill prized in today's advanced manufacturing.
- **ORGANIZED:** Because they often play so many roles in balancing family and work, women know how to organize their responsibilities and time.

Dr. Myrna Reyes, Research & Development Engineer, Trumpf Inc.

> ***Women belong in manufacturing because they bring a needed diversity and new perspectives to the workforce.***
>
> Karen Wosczyna-Birch, Executive Director COT-Regional Center for Next Generation Manufacturing

> ***I think women succeed in manufacturing because we can see the bigger picture because we have to play multiple roles.***
>
> Sabrina Richmond, Program Quality & Compliance Manager, UTC Aerospace Systems

> ***I think that women belong in manufacturing because in addition to our ability to come with the right credentials for doing the job, we also bring to the table a focus on the work environment, the people that we're working with—the relationship piece of it.***
>
> Kathy Saint, President & Owner, Schwerdtle Stamp Company

This part of the teacher's guide encourages your female students to look at why manufacturing careers could be attractive to them. It would be a good idea to show the Overview segment of the DVD at this time.

What Are the Advantages for Women in Manufacturing?

The advantages of a manufacturing career for women are endless and include:

Upward mobility—Today, more than ever, manufacturers are looking for women to take on greater management roles. Unlike in the past, when women were often denied access to management opportunities, women today are more apt to be recognized for their leadership abilities. But there is still a long way to go—among women in manufacturing, only about 27% hold management positions. The opportunities for women leaders are limitless.[7]

> ***"We very often see that the more successful companies have a good balance between men and women in leadership.***
>
> Carol Wallace, President & CEO, Cooper-Atkins Corporation

Flexibility—Manufacturing environments often allow for greater flexibility on the job, which is particularly beneficial for working mothers who may require a nontraditional work schedule.

Diverse work responsibilities—In today's advanced manufacturing, workers play many different roles. Manufacturing workers interviewed in the accompanying DVD have one thing in common—they all said they never get bored on the job because there is something different to do every day.

Variety of careers—There are many different kinds of careers within manufacturing, including marketing managers, accountants, computer-aided design (CAD) technicians and quality control coordinators. While formal community college and university training beyond high school is ideal, many manufacturers will cross-train employees to become proficient in a variety of areas outside of their normal area of expertise.

> ***"The opportunities are tremendous. If you think about sitting on a plane and looking out at the wing and all the intricacies it takes to make that plane fly, you can say to yourself, how great is it that I'm part of this.***
>
> Bonnie DelConte, President, Connecticut State Technical Extension Program (CONNSTEP)

Excellent benefits—Many manufacturing companies offer tuition reimbursement, retirement plans, and the opportunity to supplement earnings with overtime hours. Earnings are also higher than average, with manufacturing workers making $76,060 in annual wages and benefits, compared to the average worker in other industries making $60,168.[8]

High-tech environment—Manufacturing today is infused with cutting edge technology that is changing the industry and the world. Additive manufacturing or 3-D printers are already revolutionizing manufacturing by creating models of a potential product in a matter of minutes using a digitalized process. The resulting prototype allows for products ultimately to be manufactured more precisely and efficiently.

Humanitarian impact—One benefit especially attractive to women is that many manufacturing companies produce products that directly benefit people, such as iPads, iPhones, medical devices, X-ray machines, and equipment used in research. Biomedical engineers design and create artificial limbs, and machine operators mold and cut the pieces that make the limbs.[9]

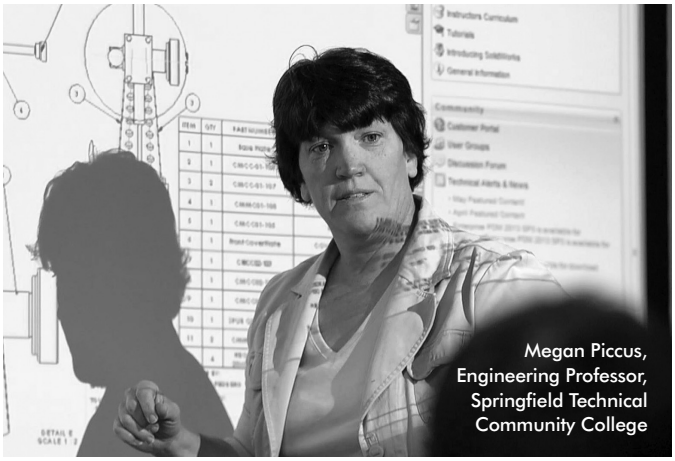
[7] How Manufacturers Can Attract, Retain and Advance Talented Women: Deloitte and the Manufacturing Institute, 2013; [8] "Made in the USA; Manufacturing Is Back—but Where Are the Jobs?" Time Magazine, April 22, 2013; National Association of Manufacturers (January 2009); [9] "Manufacturing: Not Just a Man's Job," CNN/Money, Sept. 4, 2012

Part Two Recruiting and Retaining Women in Manufacturing

What Can You Do as an Educator?

Convincing your female students to consider careers in manufacturing can be challenging. How can you as an educator put young women on the right path toward a manufacturing career? Here are a few suggestions[10]:

- Work on changing the assumption that only males should pursue science-based careers, and females should pursue careers in the humanities or social sciences. More than 70% of the 500,000 people surveyed around the world indicated that they associated science with "male" and the arts with "female." In reality, girls today earn higher grades in math and science than boys. Let your female students know that they are equally capable as boys of achieving success in manufacturing.
- Instill in your female students the notion that they can acquire manufacturing skills, as too many of them believe they can't. Especially focus on spatial skills (being able to view blueprints, the mental rotation of objects, etc.) because they are often essential in manufacturing. Most girls at a young age aren't encouraged as much as boys to do anything mechanical. Therefore, encourage your female students to work with their hands, and draw whenever possible, or introduce them to a practical course in spatial skills that will help build their confidence.


Megan Piccus, Engineering Professor, Springfield Technical Community College

- Let your female students know that through persistence and effort they can improve their abilities.
- Many manufacturing training programs don't discuss the broader impact that manufacturing has on society, such as the impact that manufacturers have in creating such products as wheelchairs, X-ray machines, computers, cars, and how they supply the materials to build buildings and bridges, to name a few. Help your female students understand how manufacturing creates a better life and the environment around them.
- Inform your female students that there is a wide variety of manufacturing jobs going unfilled today. According to a report by the Center for Regional Economic Competitiveness[11], manufacturers are desperately in need of not just production workers but also sales representatives, engineers, managers, and computer systems analysts. All of these jobs pay very well and provide good benefits as well as mobility.
- Provide information about manufacturing jobs in demand by inviting speakers into your classroom to talk about today's manufacturing careers or by bringing students to a local manufacturing company for a visit. Encourage job shadowing and internships where they can be mentored by successful women in manufacturing.

Last but not least, use the exercises and information in this guide to provide a greater understanding of what manufacturing is and what careers might be appealing. And be sure to show the profiles in the accompanying DVD of women from all aspects of life who have made educated choices to pursue successful careers in manufacturing.

[10] "10 Ways to Attract Women in Manufacturing," Bert Maes, blog at WordPress.com, March 25, 2010; [11] U.S. Manufacturing Jobs: Where the Companies are Hiring, Center for Regional Economic Competitiveness, November, 2011

TEACHER REPRODUCIBLE. Use this page to help young women understand manufacturing career opportunities.

What Are the Opportunities in Manufacturing?[12]

CNC Programmers and Operators: Work with CNC (computer numerically controlled) machines, which cut and shape metal, plastic, or glass to form a finished part. CNC programmers plot out, step-by-step, the way a machine will make parts to meet exact standards. Once the programming is done, CNC operators step in to keep an eye on the machine all the way through the manufacturing process.

Drafters (CADD—Computer Aided Design and Drafting): CADD operators use computer software to prepare technical drawings and plans that are used to build everything from manufactured products such as toys, spacecraft, and industrial machinery to oil and gas pipelines. They review engineering drawings and designs to ensure that the right specifications and standards are used.

Machinists: Machinists make things with metal and other materials, such as plastic and glass. Lathes, milling machines, shapers, and grinders are all part of their daily work. They run computer-controlled machining tools that are accurate down to a few micrometers and use finishing tools to perfect the product. They are responsible for metalworking projects from planning and fabrication through assembly, inspection, and testing, using knowledge of machine functions, metal properties, and mathematics.

Manufacturing Engineers: Design, develop, test and help manufacture machines, consumer products, computer software, communications systems, and more. Manufacturing engineers work with all aspects of manufacturing, from production control and quality to materials handling to automation. Depending on the engineering specialty, an engineer could be in charge of building everything from bridges and solar panels to computer chips and medical lasers. They create a plan, execute it, manage people and budgets, and report on their programs.

Manufacturing Technicians: Nearly every product you see and use is manufactured, including cars, computers, refrigerators, music systems, bikes, video games, sports equipment, aircraft, and medical devices. Manufacturing technicians operate, install, maintain, check for quality, and continuously improve the machinery, processes, and production systems that produce these products.

Tool and Die Makers: Design, build and repair machine tools that are used to cut, shape and form metal and other materials. Die makers construct metal forms, called dies, that shape metal in stamping and forging operations. They make metal models for die casting of parts and work with engineers and designers to determine how best to manufacture a part. They also repair worn or damaged tools, dies, gauges, jigs and fixtures.

Welders: Welders fuse or unite pieces of metal together by softening with heat or hammering, compressing the pieces together. Precise hand-eye coordination and a great attention to detail are a necessity to get the welds looking smooth. They also create parts from scratch, checking tolerances to make sure the welds are perfect. There are many types of welding including Metal Arc, Atomic Hydrogen, Submerged Arc, Resistance Butt, Flash, Spot, Stitch, Stud, and Projection.

Jessica Templeton, Welder, CAMM Metals

[12] *2011 Survey of Connecticut's Manufacturing Workforce, CBIA and the College of Technology's Regional Center for Next Generation Manufacturing; May 2010 Connecticut State Occupational Employment Statistics; Bureau of Labor Statistics, Occupational Outlook Handbook*

TEACHER REPRODUCIBLE. Use this page to help young women understand the importance of manufacturing to our economy.

MADE IN THE USA
Surprising Facts about Manufacturing[13]

Did you know that:

- The average earned hourly manufacturing worker's wage is $24.11 (up from $2.47 in 1960).
- 53% of manufacturers have some college education.
- 1 in 10 manufacturing employees has a graduate or professional degree.
- Top three American industries: food, chemicals, and complex machinery
- 12 million—number of Americans employed directly in manufacturing—9% of the workforce
- $77,060—average U.S. manufacturing worker's earnings in 2011, including pay and benefits, compared with an average of $60,168 for workers in all industries.
- 500,000—number of manufacturing jobs created in the U.S. in the past three years
- The U.S. is the world's largest manufacturing economy, producing 21% of global manufactured products. China is second at 15%.
- U.S. manufacturers perform two-thirds of all research and development in the nation, driving more innovation than any other sector.

[13] *"Made in the USA; Manufacturing Is Back—but Where Are the Jobs?" Time Magazine, April 22, 2013; National Association of Manufacturers*

TEACHER REPRODUCIBLE. Use this page to help students recognize the skills and education requirements for manufacturing careers.

Is Manufacturing For Me?

Manufacturing might appeal to you if you…

- Enjoy figuring out how things work
- Like to make a difference in peoples' lives
- Like solving practical problems
- Have an interest in making things—especially using technology, electronics, lasers and robots
- Enjoy developing new techniques and products
- Like taking things apart and putting them back together
- Enjoy working in teams
- Like math

Shelby Baker,
Test Technician,
Whelen Engineering

What Skills and Characteristics Would Help Me Succeed and Advance in Manufacturing?

Employers cite the following characteristics and skills as important for success and advancement in manufacturing[14]:

- Comprehension and communication skills
- Ability to work with existing technology
- A desire to learn new skills/technologies
- Strong math, science, and problem-solving skills
- Teamwork/interpersonal skills
- Cross-training—the ability to transfer skills and learn new ones in order to perform many functions in the workplace
- Professionalism, including punctuality, positive attitude, and appropriate attire
- Ability to work successfully with people from diverse backgrounds and cultures.

CBIA's *2011 Survey of Connecticut's Manufacturing Workforce,* on behalf of the Regional Center for Next Generation Manufacturing, listed the following skills as the most essential:

- Employability, work ethic, punctuality
- Basic skills (math, reading, writing)
- Technical skills (CNC, blueprint reading, job-specific)
- Advanced skills (problem-solving, computer, scientific)

[14] *Occupational Employment Wages—Hartford Market, 2012, Connecticut State Department of Labor*

TEACHER REPRODUCIBLE. Use this page to help students understand education requirements and average salaries for manufacturing careers.

What Are the Education Requirements and Average Salaries?

Salaries listed are based on information from the Connecticut State Department of Labor, Hartford Market, 2012.[15]

FOR INDIVIDUALS WITH A HIGH-SCHOOL DIPLOMA, APPRENTICESHIP, AND/OR ASSOCIATE DEGREE

Occupation	Average Salary
CADD/Drafter	$47,000
CNC Operator	$42,000
CNC Programmer	$54,000
Crushing, Grinding, Polishing Machine Setters	$33,000
Engineering Technician	$58,000
Lathe and Turning Machine Tool Setters	$44,000
Machinist	$45,000
Mechanical Engineering Technician	$60,000
Metal/Plastic Workers	$40,000
Milling and Planning Machine Setters	$48,000
Prepress Technicians/Workers	$42,000
Production Workers	$26,000
Stationary Engineers and Boiler Operators	$63,000
Test Technician (Inspectors)	$46,000
Tool and Die Maker	$52,000
Welder/Solderer	$42,000

FOR INDIVIDUALS WITH A BACHELOR'S DEGREE OR HIGHER

Occupation	Average Salary
Aerospace Engineer	$87,000
Biomedical Engineer	$90,000
Chemical Engineer	$90,000
CNC Programmer (4 yr. degree)	$68,000
Electrical Engineer	$82,000
Industrial Engineer	$81,000
Manufacturing Engineer	$78,000
Mechanical Engineer	$78,000
Operations Manager	$100,000
Quality Control Manager	$100,000

Considerable overtime pay is available in manufacturing, often resulting in higher earnings than those listed.

[15] *Occupational Employment Wages—Hartford Market, 2012, Connecticut State Department of Labor*

TEACHER REPRODUCIBLE. Use these pages to help students understand manufacturing's impact on Connecticut's economy. Refer to the DVD profiles for hints.

Part Three Manufacturing—Then and Now

Connecticut Pride—Creating a Better World Through Manufacturing

Connecticut manufacturing has a proud past and a strong presence in today's economy. Fifty of Connecticut's top 100 companies are manufacturers.

While you may be familiar with more well-known products like airplane engines from Pratt and Whitney and helicopters made by Sikorsky, there are many other prominent products that originated in Connecticut that are still being manufactured. Can you name Connecticut products from the past? Look around you. Can you name Connecticut made products today and the companies that produce them? Test your Connecticut manufacturing I.Q. **(If you want hints, check out the profiles on the DVD.)**

1. Communities hear loud warning sirens and police cars use flashing lights made by this company.

   _____

2. Manufacturers buy laser machines from this German company, with operations in Connecticut, that is one of the largest suppliers of fabricating machines in North America.

   _____

3. Your coffee maker uses pumps made by this Connecticut manufacturer.

   _____

4. Submarines benefit from the life support and atmosphere monitoring systems supplied by this company.

   _____

5. The North American branch of this leading international supplier of medical laboratory equipment specializes in pipettes and centrifuges.

   _____

6. Erector sets were manufactured by this New Haven company in the 1900s.

   _____

7. These well-known kids' sneakers were first manufactured in Connecticut. Name the product and company.

   _____

8. Two prominent typewriter manufacturers once made their homes in Connecticut. Name them.

_____

_____

9. These high-quality blue jeans are handmade by this Connecticut manufacturer.

_____

10. This famous organ company began in 1899 and is still making organs today.

_____

11. If you are a tea lover, more than likely you've had a cup of one of this Connecticut-based company's teas.

_____

12. Your manicurist probably used this company's nail clippers to trim your nails.

_____

13. This company, founded in Hartford in 1877, manufactured cars, motorcycles, and bicycles under the Columbia brand name.

_____

14. If you have an old grandfather clock, chances are it was made by this famous clock company.

_____

15. First manufactured in Connecticut in 1866, this well-known astringent continues to offer relief from sores and swellings. The current Connecticut manufacturer of this product is the world's leading maker and supplier. Name the company and product.

_____

16. Santa Claus and your local farmer's cows probably use one of this company's bells.

_____

_____

_____

ANSWER KEY

1. *Whelen Engineering*
2. *Trumpf, Inc.*
3. *Dymotek, Inc.*
4. *United Technologies Aerospace Systems*
5. *Eppendorf, Inc.*
6. *A.C. Gilbert Co.*
7. *Keds; U.S. Rubber (Uniroyal)*
8. *Royal Typewriter, Underwood Typewriter*
9. *The Hartford Denim Company*
10. *The Austin Organ Company*
11. *R.C. Bigelow*
12. *W.E. Basset Company*
13. *Pope Manufacturing Company*
14. *Seth Thomas Clock Company*
15. *Dickinson Brands, Inc.; Witch Hazel*
16. *Bevin Bell Company*

TEACHER REPRODUCIBLE. Use these pages to give students an appreciation for women engineers who have made an impact.

Notable Women in Engineering—Making a Difference

Engineers play a crucial role in manufacturing. Although women's numbers in engineering rank consistently much lower than their male counterparts (only 10% of all engineers), they historically and consistently have made significant advancements to make our society a better place to live. Here are just a few examples of notable women who have made major contributions in their field.[16]

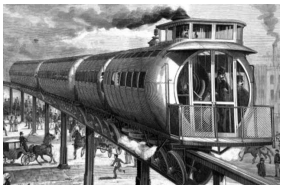
Martha J. Coston developed signal flares that are still used today by the U.S. Navy.

1859

Helen Augusta Blanchard held 28 patents, most notably related to sewing machines, the most famous being the zigzag stitch machine.

1873

1879-81



Mary Walton developed a method to detect smoke emissions and methods to reduce train noise and was a pioneer in reducing air pollution in trains and industrial and residential chimneys during the Industrial Revolution.

1903

Mary Anderson, noticing that streetcar drivers had to open the windows of their cars when it rained, invented the windshield wiper in 1903. By 1916, they were standard equipment on all American cars.

Student activity: Daredevils of the classroom (Solar Hot Dog Maker)

Manufacturing involves several processes before a product is produced: market analysis, design, fabrication, testing, marketing, distribution, and recycling and reuse. Engineers are the people who come up with the ideas, design the product, test it, and help manufacture it. Here's an exercise on how you can bring a product to life by thinking like an engineer.

Materials:

- Cardboard box
- Poster board
- White glue
- Skewer (or cut piece of coat hanger without a point)
- Tin foil
- Utility knife
- Hot dogs

Directions:

1. Cut the top flaps off of a long, narrow cardboard box so that the top has nothing covering it.
2. Measure and cut the poster board so that the width matches the width of the box and the length is longer than the box (the poster board should dip down inside the box). Tape each end of the poster board to the ends of the box, allowing the middle to hang down inside the box.
3. Cut a piece of aluminum foil the exact size of the poster board. After putting white glue on the poster board, put the aluminum foil over it, shiny side facing up toward you. Keep it as smooth as you can for the best cooking results.
4. Punch a hole in the long side in the box near where the light is concentrated the most. Make sure the two holes are directly across from each other and just big enough to fit the skewer. Put your hot dog on the skewer and put each side of the skewer in each hole that you made. Place in a sunny spot and watch it cook.

Now that you've engineered and tested a solar hot dog cooker, analyze how you are going to produce it so that it's profitable and think about how will you market and distribute it.

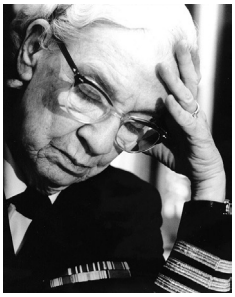
Women Leaders in Engineering Today

Marissa Mayer, CEO of Yahoo, was Google's first female engineer and helped develop its search technologies and key products including images, maps, news, and the toolbar.

Anna-Maria R. McGowan, Project Manager, NASA, designs cutting-edge technology for air vehicles of the future.

Alicia Boler-Davis, Senior Vice President, Global Quality & Customer Experience, General Motors, was the first GM plant manager to also lead a vehicle launch—for the Chevrolet Sonic.

Grace Murray Hopper designed a series of computers at Harvard in 1944 and pioneered standards for COBOL, a prominent computer language still used today.



1960

1964

1978

1975

1942

1926-30

Lillian Gilbreth, recognized as the "mother of modern management," was the first American engineer to create a synthesis of psychology and scientific management. She developed time and motion tools for industry still used today, and a fatigue study which is the forerunner of ergonomics.

Hedy Lamarr, a famous 1940s actress, invented a sophisticated and unique anti-jamming device that today is the basis for technology used in cell phones, WiFi internet, and satellite communications..

Stephanie Kwolek's discovery of a polymade solvent led to the production of Kevlar in 1971, the crucial component used in canoe hulls, auto bodies, and bullet-proof vests.

Elsa Garmire made advances in optical devices and quantum electronics that made the commercial use of lasers used in CD players and printers feasible.

Bonnie Dunbar— One of the most experienced astronauts in the world who flew on the space shuttle, developed ceramic tiles to protect space capsules on reentry and flew on several NASA space missions.

[16] *The Nolan/Lehr Group, Ellen Morrissey, ewwk.org; che.wsu.edu; engineergirl.org; engineeringdegree.net;*

TEACHER REPRODUCIBLE. Watch the profiles section of the DVD to get an up-close look at some women in manufacturing careers, and answer the questions below. (Answer key on page 2)

Part Four Meet Today's Women in Manufacturing

1. Who wanted to be an astronaut? What does she like about her job?

2. Who earned a scholarship at Asnuntuck Community College? What does she like about her job?

3. Who travels all over the world as part of her job? What does she like about her job?

4. Who tests LED lights for police cars? What does she like about her job?

5. Who left manufacturing to become an accountant, only to return to her passion—manufacturing? What does she like about her job?

6. Who thinks being a woman in manufacturing has its advantages? What does she like about her job?

TEACHER REPRODUCIBLE. Use this page to help students understand how products are manufactured.

Part Five Understanding the Manufacturing Process

What Is Manufacturing?

This part of the teacher's guide encourages female students to think about manufacturing and the processes behind the products we use. The following activities are suggested to encourage students to think about what goes into manufacturing and how manufacturing touches our lives every day.

Before showing the DVD, remind students that almost everything in our daily lives—from headphones to lipstick tubes—has been created and manufactured by someone. Ask your female students to identify products in their purses that have been manufactured.

- What is the item made from?
- How do you think it was made?
- Start to finish, what types of workers were involved in the concept, design, sourcing, funding, testing, marketing, distribution, and disposal associated with this product?

Student Activity: Team Discussions of Student-Manufactured Products

Divide students into small groups and have them discuss any product they may have created from scratch or altered for a purpose. These could include pinewood or soapbox derby cars, baked goods, science projects, jewelry, wallets, bird feeders, arts and crafts, and tie-dyed or silkscreened shirts. Have students share how they came up with the idea and how they designed the product. If they sold their products, ask them to describe that process as well. Have them write down the steps they took to make their products successful. Also, have them discuss any mistakes they may have made and what they did to correct the problems. Have a team leader report key findings to the class.

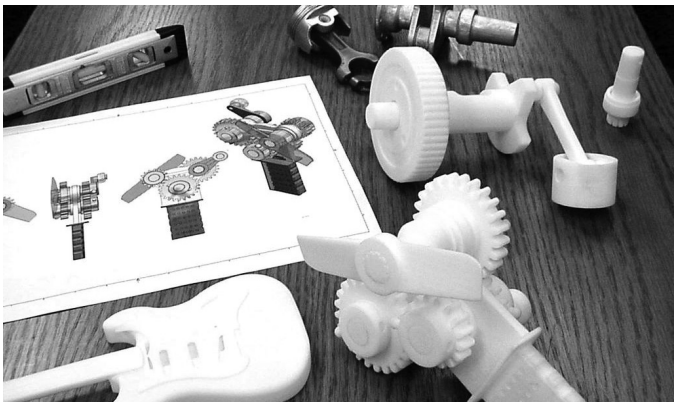
TEACHER REPRODUCIBLE. Use this page to help students understand manufacturing processes.

Factory in a Box—Additive Manufacturing

One rapidly growing manufacturing process is called additive manufacturing. Additive manufacturing, also known as rapid prototyping and 3-D printing, is when a part is made layer by layer. The idea is not new. For example, in ancient Egypt, pyramids were built in a layer-by-layer fashion.

With rapid prototyping, plastic material in powder or liquid form is solidified by a power source (such as a laser or by hot plastic filaments injected through a nozzle) to create a digitalized or scanned model. This process can create extremely complex shapes based on these models.

The benefit of making a plastic prototype of a product by using rapid prototyping is that the customer and manufacturer get a more accurate depiction of the product before it's actually produced. Rapid prototyping also can take an old part in need of being reproduced (reverse engineering) and determine its former blueprint and how it was manufactured.



You can find extensive information on 3-D printing in all areas of manufacturing, including the food industry, organ tissue reproduction, and the textile industry. The aerospace industry is also embracing 3-D printing of metallic parts. Look for metal laser sintering in your search.

Student Activities

Reverse Engineering: Take a simple non-electrical product that can be taken apart without breaking any component, a product where its components are mechanically put together using screws or sliding interlocking mechanisms. This could include toys, household products, etc. Start disassembling the product. Take a digital picture of every stage of disassembly. As you take the parts off, discuss the possible reason for the component's role in the assembly and the part. Once the product is fully disassembled, arrange the parts in a logical order. Reassemble the product and discuss the role and reason for the parts as you are reassembling them. Ask yourself whether any of the parts can be eliminated and the design simplified in a future model of the product. Turn this experiment into a lab report.

Rapid Prototyping—Part 1: (Contact your local community college's College of Technology engineering technology pathway if you don't have access to 3-D CAD software and a 3-D printer.) Create a solid model using a 3-D CAD software (such as Solidworks®, Inventor®, Creo® (formerly Pro/E), KeyCreator® (formerly Cadkey), Unigraphics® NX, etc.) After saving the model in the respective file type of the software, also save it as an STL file type (STL stands for stereolithography). Save the file on a USB drive and take it to a 3-D printer. Using an expert or your own learned expertise print the part. Some reflection ideas: Would you change anything in the design of the part to make the production time shorter or the part stronger?

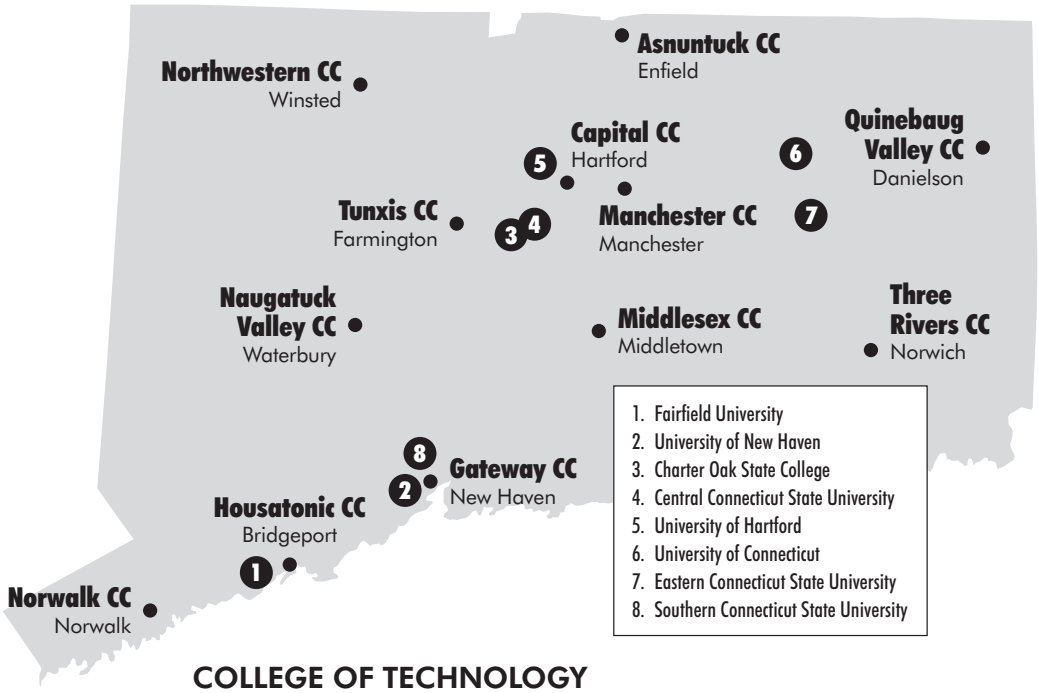
Rapid Prototyping—Part 2: Using your experience in creating a model in the Rapid Prototyping above, create an assembly in the 3-D CAD software and turn it into a STL file. If the rapid prototype machine that you have access to has the capability, can it create the assembly and after it is finished, do the parts move? (i.e., engaged gears such as in cam assemblies or adjustable wrenches).

Watch the College of Technology segment of the DVD to see how your students can prepare for a career in manufacturing.

Part Five Getting There—Your Career Pathway

Anyone entering a manufacturing career would be better prepared and have more opportunities with additional education. Associate degree students will advance and earn higher wages in addition to being able to pursue higher level professions like engineering.

The Regional Center for Next Generation Manufacturing (RCNGM) addresses the need for highly skilled workers in the new manufacturing workplace by building programs that provide resources to educators and students interested in learning new technologies in manufacturing. A National Science Foundation Center of Excellence, the RCNGM is directed by the Connecticut College of Technology.



COLLEGE OF TECHNOLOGY
Community Colleges & 4-Year Partner Institutions

The Connecticut College of Technology (COT) is a virtual organization representing the engineering and technician degree programs offered at the state's 12 community colleges. This innovative curriculum enables students who have graduated from a Technological Studies or Engineering Science program to transfer all credits to four-year engineering and technological studies programs at select Connecticut four-year universities.

The COT works closely with industry and Connecticut universities to get the most up-to-date information on workforce needs. The associate degree programs are tailored around careers in high-growth fields, such as:

- Precision machining
- Fiber optics
- Precision metal fabrication

Industry-driven courses and certificate programs are offered in such areas as:

- Computer-aided design (CAD)
- Lean manufacturing and supply chain management
- Plastics technology
- Biomolecular science
- Manufacturing engineering technology
- Welding technology
- Laser and fiber optic technology
- Machine technology

This pathway is particularly beneficial to engineering students as, once accepted through the admission process, they can enter as a junior at partner institutions.

For more information, visit nextgenmfg.org.

COLLEGE OF TECHNOLOGY
Connecticut Community Colleges

Next Generation Manufacturing Center

NSF

www.nextgenmfg.org

A National Science Foundation Center of Excellence

What You Can Do

To Be Part of the Next Generation of Manufacturers

The Regional Center for Next Generation Manufacturing provides great resources for both educators and students interested in exploring opportunities in today's technology companies. Funded by the National Science Foundation and directed by the Connecticut Community Colleges' College of Technology, the Center offers:

- Industry-driven courses in next generation manufacturing, including laser manufacturing, green engineering, nanotechnology, fuel cells, and biomedical applications
- Online courses that include diverse methods of teaching
- Career marketing materials that support the recruitment and retention of students in manufacturing careers
- Courses that bridge two-year engineering technology programs with traditional four-year engineering programs
- Longitudinal studies that identify best practices and assess students' performance in the workplace and employer satisfaction with graduates
- Teacher internships in cutting-edge, next generation manufacturing companies

Start by enrolling in College of Technology programs.

The Connecticut Community Colleges' College of Technology offers a specialized curriculum that allows a student to complete an A.S. degree in *Technological Studies* or *Engineering Science* at any one of the state's twelve community colleges:

- Asnuntuck
- Capital
- Gateway
- Housatonic
- Manchester
- Middlesex
- Naugatuck Valley
- Northwestern CT
- Norwalk
- Quinebaug Valley
- Three Rivers
- Tunxis

Connecticut's community colleges are affordable, flexible, and geographically convenient for students statewide. They offer programs to prepare students for careers in high-growth fields, such as precision machining, fiber optics, and next generation manufacturing.

A.S. degree options and credit certifications include:

ENGINEERING SCIENCE

TECHNOLOGY STUDIES

- **Computer Aided Design (CAD)**
- **Laser and Fiber Optic Technology**
- **Plastics Technology**
- **Precision Manufacturing**
- **Environmental Science**
- **Lean Manufacturing and Supply Chain Management**
- **Manufacturing Engineering Technology**
- **Engineering Technology**
- **Biomolecular Science**
- **Machine Technology**
- **Welding Technology**
- **Electromechanical Technology**

Engineering Science also provides a seamless pathway for community college students to continue their program of studies as juniors in engineering programs at the University of Connecticut, Fairfield University, the University of Hartford, University of New Haven, Central Connecticut State University, Eastern Connecticut State University, Southern Connecticut State University, or Charter Oak State College. Technology Studies allows students to matriculate as a junior at the University of Hartford or Central Connecticut State University.

For more information, visit our website at nextgenmfg.org.

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COLLEGE OF TECHNOLOGY
Connecticut Community Colleges

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