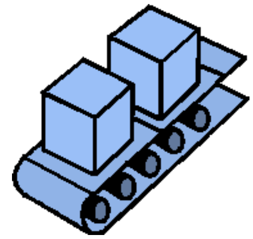
Assembly Line



Provided by TryEngineering - www.tryengineering.org

Lesson Focus

This lesson demonstrates the power of mass production. Students work in teams to design, construct, test, and redesign an assembly line to manufacture a product as quickly and efficiently as possible to meet the quality control criteria.

Lesson Synopsis

Students work individually to assemble a product and then work in teams to design, construct, test, and redesign an assembly line process whose product must meet specific quality control criteria. Students reflect and have a classroom discussion comparing the two approaches.

Age Levels

8-18

Objectives

During this lesson, students will:

- Assemble a product individually that meets the quality control criteria.
- Design an assembly line process to assemble a product as quickly and efficiently as possible meeting the quality control criteria.
- Construct an assembly line.
- Test and redesign the assembly line process.
- Compare the difference between assembling a product individually versus with an assembly line.

Anticipated Learner Outcomes

As a result of this lesson, students will have:

- Assembled a project by hand that meets the quality control criteria.
- Designed an assembly line process to assemble a product as quickly and efficiently as possible meeting the quality control criteria.
- Constructed an assembly line.
- Tested and redesigned the assembly line process.
- Compared the difference between assembling a product individually versus with an assembly line.

Lesson Activities

- Students will time themselves as they assemble a product individually that meets quality control criteria. Next, as a team they will design, construct, test and redesign an assembly line process, and finally they will compare the difference between assembling a product individually versus with an assembly line.

Resources/Materials

- Teacher Resource Documents (attached)
- Student Worksheets (attached)
- Student Resource Sheets (attached)

Alignment to Curriculum Frameworks

See attached curriculum alignment sheet.

Internet Connections

- Online Video: Assembly Line: Crayola Crayons (http://videos.howstuffworks.com/discovery/4269-assembly-line-crayola-crayons-video.htm)
- History Channel -- the Assembly Line (www.history.com/topics/assembly-line)
- TryEngineering (www.tryengineering.org)
- IEEE Global History Network (www.ieeeghn.org)
- ITEA Standards for Technological Literacy: Content for the Study of Technology (www.iteaconnect.org/TAA)
- National Science Education Standards (www.nsta.org/publications/nses.aspx)
- McREL Compendium of Standards and Benchmarks (www.mcrel.org/standards-benchmarks)

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Recommended Reading

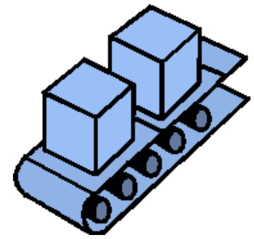
- Henry Ford and the Assembly Line (ISBN: 978-1584151739)
- The Assembly Line (ISBN: 978-0618484379)
- Lean Assembly: The Nuts and Bolts of Making Assembly Operations Flow (ISBN: 978-1563272639)

Optional Writing Activity

- Write an “explanatory essay” describing the steps of the assembly line process. Share the essays with students from another class and have them try to replicate the assembly line.

Assembly Line

For Teachers:
Teacher Resources



◆ Lesson Goal
The goal of this lesson is for students to design, construct, test and redesign an assembly line process, and finally they will compare the difference between assembling a product individually versus with an assembly line.

◆ Lesson Objectives
During this lesson, students will:

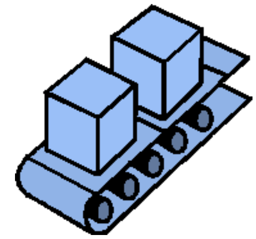
- Assemble a product individually that meets the quality control criteria.
- Design an assembly line process to assemble a product as quickly and efficiently as possible meeting the quality control criteria.
- Construct an assembly line.
- Test and redesign the assembly line process.
- Compare the difference between assembling a product individually versus with an assembly line.

◆ Materials
Activity 1: Assemble one Color Brick (per student)
- 2 brown paper bags
- 5 pieces of recycled paper 8”x 11”
- 1 set of markers
- 1 black marker
- 2 cups of different sizes or other objects that can be traced to make circles (Note: could also use a compass)
- 1 ruler
- 1 copy of the Assemble One Color Brick Worksheet
- Sample Color Brick (only need one to show class)

Activity 2: Design, Construct, Test, Redesign Assembly Line (per team)
- 30 brown paper bags (30 per team)
- Stack of recycled paper 8”x 11”
- 1 full set of markers (1 full set for each team)
- 1 black marker
- 1 stop watch
- 2-4 sets of 2 cups of different sizes or other objects or that can be traced to make circles (Note: could also use a compass)
- 4 Rulers
- Copies of the Design Challenge Worksheet (1 per student)

◆ Time Needed
- Activity 1: Assemble One “Color Brick” (1/2 hour)
- Activity 2: Design, Construct, Test, Redesign the Assembly Line (1-2 hours)

◆ Procedure
Activity 1: Assemble Color Brick Alone
1. Handout the Assemble One Color Brick worksheet
2. Introduce the design challenge scenario.
3. Share the sample Color Brick.
4. Discuss each criterion and the tools needed to assemble the product correctly.
5. Provide each student with the materials and tools need to make one Color Brick.
6. Once the task is clear and questions have been answered, set the timer and students can begin to assemble their Color Brick making sure to meet the criteria while moving as quickly as possible.
7. When a student completes the color brick they should raise her/his hand and you can write his/her name and time up on the board.
8. Have students complete the reflection questions.
9. Discuss reflection questions.



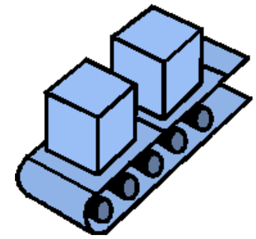
For Teachers:
Teacher Resources (continued)

Activity 2: Design, Construct, Test, Redesign Color Brick Assembly Line

1. Separate the class into two teams of 10-12.
2. Handout the Design Challenge Worksheet and discuss.
3. Have student works in their teams to design an assembly line (Engineering Design Process steps 2 & 3: brainstorm solutions and choose best solution). To make sure all students are engaged, break the two large teams into smaller teams of 2-5 and have them design an assembly line and then share with the rest of their larger team. Each large team will need to then vote on the best design for their final assembly line.
4. Have students build their assembly line (EDP step 4). Students may need to move desks into a line, circle, etc. They need to label each station and put the materials and tools at the right stations. They need to assign each person a task and a station.
5. When each team is done with constructing their assembly line, give them some time to test and redesign if necessary (EDP steps 5 & 6).
6. Set the timer to about 10- 15 minutes (base your time on how long it took teams during testing to build one). Explain to students that you will be the Senior Quality Control Officer and will be checking to make sure their Color Brick meets the criteria.
7. Have each team share their responses to Reflection Questions and have a class discussion. Make sure to compare and discuss individually assembling a product versus an assembly line.

◆ Extensions and Variations

- Add more tasks, such as packaging bricks into a box to ship.
- Change the size of the brick (use large brown grocery paper bags)
- Play some fun fast music during the assembly line testing.
- Instead of giving a time and seeing how many bricks each team makes, tell students they have to make a certain amount and see how long it takes each team.
- Have students research ergonomics and consider how the various jobs on their assembly line suit each worker. Have them make any necessary modifications for their assembly line workers. (Ergonomics is a science concerned with the 'fit' between people and their work. It puts people first, taking account of their capabilities and limitations. Ergonomics aims to make sure that tasks, equipment, information and the environment suit each worker. Source: (www.hse.gov.uk/pubns/indg90.pdf)
- Have students research robots used on assembly lines and consider how they would best utilize a robot in their assembly line. What specific job(s) would the robot perform and why?



Student Resource:
Key Vocabulary & History

Key Vocabulary

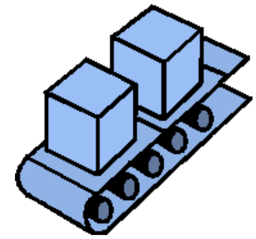
- **Manufacturing**
  The use of people, machines and tools to turn raw goods into finished products.
- **Mass Production**
  The large scale manufacturing of a product.
- **Assembly Line**
  A manufacturing process where a product is assembled by adding parts in sequence.
- **Conveyor Belt**
  A belt moved by rollers which is used to transport objects from one place to another.

History of the Assembly Line

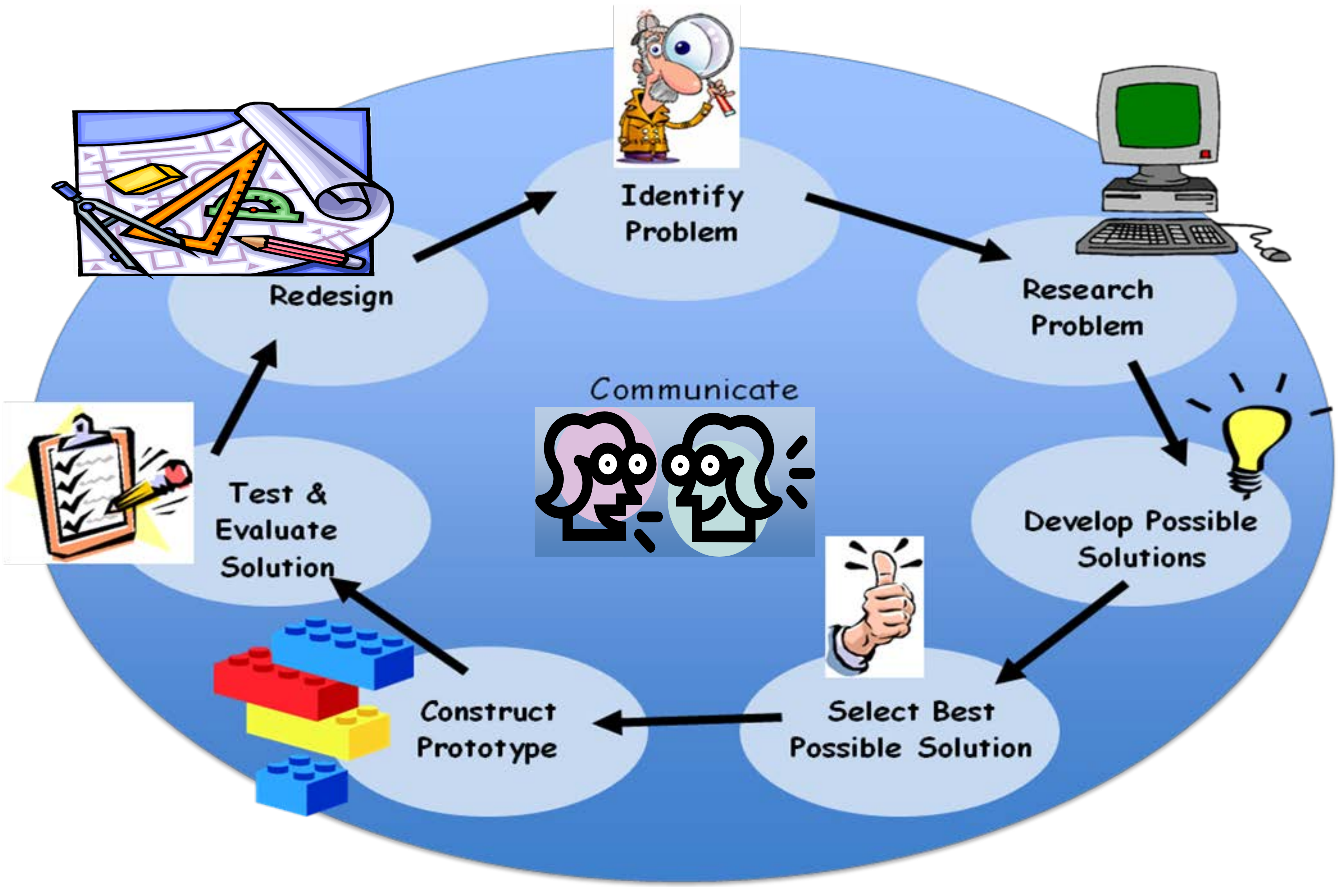
The origins of the assembly line can be traced back to miners during medieval times who used bucket elevators to the shipbuilders of the fourteenth century who created moving lines of parts. By the 1900's the assembly line was used by many industries (shipbuilding, canning, milling, meat-packing, etc.), but was most successful in the automobile industry.

Henry Ford created the Model T automobile in 1908. The car was simple so owners could fix it themselves. It was also sturdy and cheap. Soon, the Ford Motor Company started receiving so many orders for Model T's that they couldn't build them quickly enough. To speed up production, Ford changed the way the Model T was built. Instead of several groups of workers each building a complete car from the ground up, workers stayed in one spot and added parts to cars as they moved past them. Parts were delivered to the employees by conveyor belts. Ford even managed to time the delivery of a part so that it would get to a worker only when it was needed. By 1913, Ford had a complete assembly line functioning. This method of production was rapidly adopted by many industries when they discovered that mass production on assembly lines sped up manufacturing time and lowered costs.

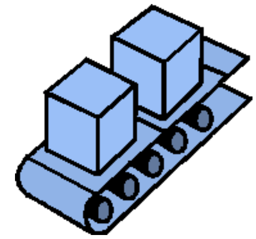
Ford used an approach for his assembly line that we call just-in-time (JIT) manufacturing today. This approach lets manufacturers purchase and receive components just before they're needed on the assembly line. As a consequence, it relieves manufacturers of the cost and burden of housing and managing idle parts. The basic elements of JIT were developed by Toyota in the 1950's and were well-established in many Japanese factories by the early 1970's. JIT began to be adopted in the U.S. in the 1980's (General Electric was an early adopter), and is now widely accepted and used.

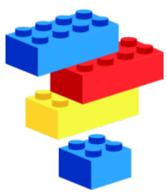


The Engineering Design Process

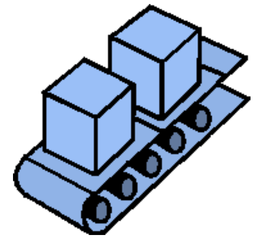


	**Identify the Problem** What is the problem you want to solve?
	**Research Problem** What do you know about the problem? Find out as much about the problem as you can. What are the criteria (conditions that the design must satisfy—its overall size or weight, etc.) and constraints (limitations with material, time, size of team, etc.) of this problem?



	**Develop Possible Solutions** Brainstorm as many solutions as possible.
	**Select Best Possible Solution** Which of your designs do you think is the best possible solution?
	**Construct Prototype** Using the materials given, build a prototype (a working model) of your design. Don't forget about the criteria (conditions that the design must satisfy) and constraints (limitations that need to be designed around).
	**Test & Evaluate Solution** Test and evaluate your design. Did you satisfy the criteria and constraints?
	**Redesign** Did your design solve the problem? If not, brainstorm a new design, build and test it until you have successfully solved the problem.
	**Communicate** At each step in the process you must communicate with your team members. You need to also communicate with others outside of your team to get feedback on your design. You need to communicate verbally as well as by describing your design thorough writing and drawings. Communication is at the core of the engineering design process.

Assembly Line



Student Worksheet:
Assemble One Color Brick

◆ **Scenario**

A local toy company is calling on engineering teams to implement time saving methods to help them meet the demands of manufacturing their most popular product— “color bricks.” This toddler toy is made out of recycled brown bags and has been hugely popular. They are constantly selling out! The toy company needs to place an order for one million color bricks in just 3 days!

◆ **Assemble One Color Brick**

See how fast you can assemble one color brick and still meet the criteria.

◆ **Criteria**

- The brick must be made up of 2 brown bags.
- The brick must be filled with 4 pieces of recycled paper (lightly crunched up and stuffed into one bag. The other bag will cover this bag and the crunched up paper.)
- The largest sides of the brick must be filled with polka dots. (3 large 1” diameter & 3 medium 0.5” circles scattered per side). One side must have 3 blue and 3 green circles. The other side must have 3 red and 3 orange circles.
- The top and bottom of the brick must have 4 vertical 0.5” purple stripes with 0.5” in between each stripe.
- Both sides of the brick must have **Color Bricks** written in black marker. Letters must be centered on the sides and 1” in height and 5” long.

◆ **Constraint**

- Use only the materials provided.

◆ **Reflect**

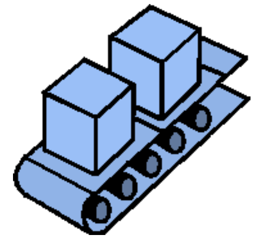
1. How long did it take you to make 1 color brick?

2. What was the easiest task and why?

2. What was the most challenging task and why?

4. Is there an easier and/or faster way to make the brick? If yes, describe

Assembly Line



Student Worksheet: Design Challenge

◆ **Scenario**
A local toy company is calling on engineering teams to implement time saving methods to help them meet the demands of manufacturing their most popular product— "color bricks." This toddler toy is made out of recycled brown bags and has been hugely popular. They are constantly selling out! The toy company needs to place an order for one million color bricks in just 3 days! They will award the contract to the engineering team that can make the bricks the fastest while meeting the quality control constraints.

◆ **Design Challenge**
Each team (approximately 8-10 per team) will design an assembly line process that will make as many "color bricks" in 10 minutes as possible and still meet all of the quality control constraints.

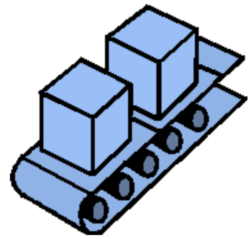
◆ **Criteria**
- Each brick must be made up of 2 brown bags.
- Each brick must be filled with 4 pieces of recycled paper (crunched up and stuffed into one bag. The other bag will cover this bag and the crunched up paper.)
- The largest sides of the brick must be filled with polka dots. (3 large 1" diameter & 3 medium 0.5" circles scattered per side). One side must have 3 blue and 3 green circles. The other side must have 3 red and 3 orange circles.
- The top and bottom of the brick must have 4 vertical 0.5" purple stripes with 0.5" in between each stripe.
- Both sides of the brick must have **Color Bricks** written in black marker. Letters must be centered on the sides and 1" in height and 5" long.

◆ **Criteria**
- You must only use the materials provided.

◆ **Planning Stage**
Meet as a team and discuss the problem you need to solve. Then develop and agree on a process for solving the challenge. You'll need to determine what materials you want to use.

Draw your design below, and be sure to indicate the description and number of parts you plan to use.

Assembly Line



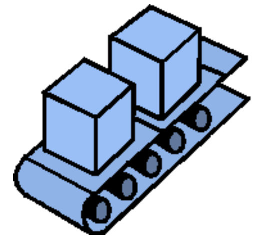
Student Worksheet: Design Challenge

Brainstorm designs for your assembly line:

Team Chosen Assembly Line Design:

◆ Construction Phase

Build your assembly line. During construction you may decide you need additional materials or that your design needs to change. This is ok – just make a new sketch and revise your materials list.



Student Worksheet (continued):

◆ Testing Phase

Each team will test their assembly line. If your design and process were unsuccessful, redesign and test again. Continue until you are happy with your solution. Be sure to watch the tests of the other teams and observe how their different designs worked.

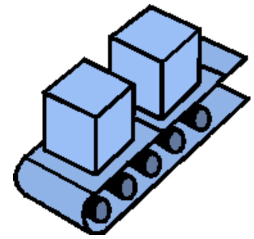
Sketch your Final Design

◆ **Evaluation Phase**

Evaluate your teams' results, complete the evaluation worksheet, and present your findings to the class.

1. Was the order of your assembly line tasks successful? If not, why?

2. Did you have enough people in your assembly line to have experts in one task? If not, how would it have changed your assembly line if you had more people?



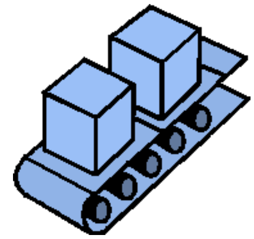
3. Did your group meet the quality control criteria? If not, why?

4. If you had more time or different supplies what would you add, change, or do differently?

5. Was it hard to go fast and still meet the quality control criteria? What would it take to improve?

6. Did your team work together harmoniously and efficiently?

7. What are the benefits of the assembly-line method when compared to assembling a product individually?



For Teachers:
Alignment to Curriculum Frameworks

Note: Lesson plans in this series are aligned to one or more of the following sets of standards:

- U.S. Science Education Standards (http://www.nap.edu/catalog.php?record_id=4962)
- U.S. Next Generation Science Standards (http://www.nextgenscience.org/)
- International Technology Education Association's Standards for Technological Literacy (http://www.iteea.org/TAA/PDFs/xstnd.pdf)
- U.S. National Council of Teachers of Mathematics' Principles and Standards for School Mathematics (http://www.nctm.org/standards/content.aspx?id=16909)
- U.S. Common Core State Standards for Mathematics (http://www.corestandards.org/Math)
- Computer Science Teachers Association K-12 Computer Science Standards (http://csta.acm.org/Curriculum/sub/K12Standards.html)

◆National Science Education Standards Grades K-4 (ages 4 - 9)

CONTENT STANDARD E: Science and Technology

As a result of activities, all students should develop

- ✦ Abilities to distinguish between natural objects and objects made by humans

CONTENT STANDARD G: History and Nature of Science

As a result of activities, all students should develop understanding of

- ✦ Science as a human endeavor
- ✦ History of science

◆National Science Education Standards Grades 5-8 (ages 10 - 14)

CONTENT STANDARD E: Science and Technology

As a result of activities, all students should develop

- ✦ Abilities of technological design
- ✦ Understandings about science and technology

CONTENT STANDARD G: History and Nature of Science

As a result of activities, all students should develop understanding of

- ✦ Science as a human endeavor
- ✦ History of science

◆National Science Education Standards Grades 9-12 (ages 14-18)

CONTENT STANDARD E: Science and Technology

As a result of activities, all students should develop

- ✦ Abilities of technological design
- ✦ Understandings about science and technology

CONTENT STANDARD G: History and Nature of Science

As a result of activities, all students should develop understanding of

- ✦ Historical perspectives

◆Next Generation Science Standards Grades 3-5 (Ages 8-11)

Engineering Design

Students who demonstrate understanding can:

- ✦ 3-5-ETS1-1.Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- ✦ 3-5-ETS1-2.Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

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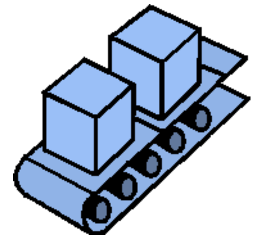

For Teachers:
Alignment to Curriculum Frameworks

◆**Next Generation Science Standards Grades 3-5 (Ages 8-11)**

Engineering Design

- 3-5-ETS1-3.Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

◆**Next Generation Science Standards Grades 6-8 (Ages 11-14)**

Engineering Design

Students who demonstrate understanding can:

- MS-ETS1-2 Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

◆**Standards for Technological Literacy - All Ages**

Technology and Society

- Standard 7: Students will develop an understanding of the influence of technology on history.

Design

- Standard 10: Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.