A Question of Balance

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Lesson Focus

Lesson focuses on the use of weight scales and measurement by manufacturing engineers. Teams of students are posed with the challenge of developing a system to fill jars with a specific weight or count of products such as marbles or paperclips.

Lesson Synopsis

A Question of Balance explores how engineers use scales and measures when designing a manufacturing process to ensure that final products are uniform in weight or count. Students explore different types of scales, and are challenged to design and build a system to deliver a uniform count or weight of marbles or paperclips into a series of four boxes or jars. They test their systems and evaluate the systems of other student teams.

Age Levels

11-18.

Objectives

- Learn about manufacturing engineering.
- Learn about manufacturing systems.
- Learn about weight packaging and consistency.
- Learn about teamwork and working in groups.

Anticipated Learner Outcomes

As a result of this activity, students should develop an understanding of:

- manufacturing engineering
- problem solving
- teamwork

Lesson Activities

Students learn how manufacturing engineers develop systems for creating consistent products. They work in a team to create a system that delivers a consistent weight or count of marbles or paperclips to a series of jars. Teams plan their system, execute the system, evaluate their own results and that of other students, and present to the class.

Resources / Materials

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

Alignment to Curriculum Frameworks

See attached curriculum alignment sheet.

Internet Connections

- TryEngineering (www.tryengineering.org)
- Jelly Belly Virtual Factory Tour (www.jellybelly.com/Virtual_Tour/virtual_tour.aspx)
- Hershey Chocolate Virtual Factory Tour (www.hersheys.com/discover/tour_video.asp)
- Tootsie Roll Industries Virtual Factory Tour (www.tootsie.com/gal_tour.php)
- 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)

Recommended Reading

- Manufacturing Engineering and Technology (ISBN: 0131489658)
- Scales and Balances (ISBN: 0747802270)

Optional Writing Activity

- Write an essay or a paragraph about the implications of automation processes on society.

A Question of Balance

For Teachers:
Teacher Resource

◆ Lesson Goal

Explore manufacturing engineering and manufacturing system design through the construction of a system to deliver equal weight or count of marbles or paperclips into a series of four boxes or jars. Students work in teams to design a system, build a system, test the system, and then evaluate their experience and report to the class.

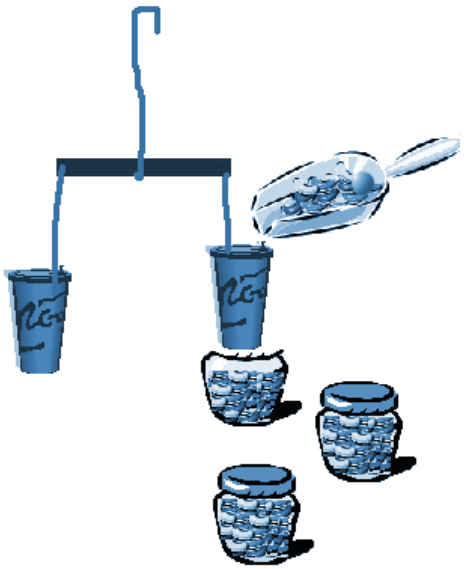
◆ Lesson Objectives

- Learn about manufacturing engineering.
- Learn about manufacturing systems.
- Learn about weight packaging and consistency.
- Learn about teamwork and working in groups.

◆ Materials

- Student Resource Sheet
- Student Worksheets
- Scale (for checking student work)
- Boxes of marbles, paperclips, or other items of consistent size and shape.
- One set of materials for each group of students:
    - Wooden dowels, plastic bowls or paper cups, wire, tape, string, four canning jars or small empty boxes

◆ Procedure



1. Show students the various Student Reference Sheets. These may be read in class, or provided as reading material for the prior night's homework. To get a feel for the manufacturing process, students may wish to visit some of the recommended websites to see how candy is manufactured.

2. Divide students into groups of 2-3 students, providing a set of materials per group.

3. Explain that students are now "engineers" and have been given the assignment of designing a system to "manufacture" four packages (boxes or jars) of a product (marbles or paperclips) of equal weight or count. The idea is that their system will generate consistent end packages. The example to the right is a very simple version…students may want to develop ramps or conveyor belts, tipping mechanisms, or other methods to deliver the candy to the final package.

For Teachers:
Teacher Resource (continued)

4. Students meet and develop a plan for their manufacturing system. They draw their plan, and then present it to the class for feedback.

5. Student groups build their system. They may rework their design in the manufacturing phase, but should make notes of what changes they needed.

6. Each student group evaluates the results, completes an evaluation/reflection worksheet, and presents their findings to the class.

◆ Tips

- Once all teams have a working system, let students view each other's work.

- The teacher should watch one packaging process, and also weigh all jars to make sure they are close to the goal weight or count. There will be some differences, but the difference should be no more than one or two marbles, assuming the weight is the same for each.

- Let the students dream up their own designs, but they may need suggestions for setting up the weight -- using a standard weight or a paper cup already filled with the desired weight of product is a simple way to solve the problem.

- You'll need to decide what the goal weight/count for each team is, based on the item (marble, paperclip) you select and the strength of the paper cups or other materials used.

◆ Time Needed

Three to four 45 minute sessions

Student Resource: Scale Applications

◆ Scales Have Many Uses

Scales are used in many applications -- beyond determining personal weight. They are an integral part of many systems, as the weight of products or components impacts the costs of products or services. For example, postal systems all over the world base the cost of delivery on the weight of the letter or package being transported. Grocers and fruit markets use scales to determine what to charge for fruits, vegetables, nuts, grains, and spices. In these examples, the weight may be a little off one way or the other without causing any difficulty. You may get an extra nut or two, or end up with a pinch less spice without implications.

◆ Manufacturing Engineering

For manufacturing engineers, particularly those in the pharmaceutical industry, it is critical for weights or products or components to be accurately measured prior to packaging. Drug manufacturers must be sure the dose is exact -- close is not good enough! Safety is a top manufacturing consideration!

Manufacturing engineers are involved with the process of manufacturing from planning to packaging of the finished product. They work with tools such as robots, programmable and numerical controllers, and vision system to fine tune assembly, packaging, and shipping facilities. They examine flow and the process of manufacturing, looking for ways to streamline production, improve turnaround, and reduce costs. One of the measures they focus on is weight. They sometimes use cameras to count the number of products that go into a package, such as the number of cookies in a box, but they very frequently use scales to make sure that the promised amount of candy, cereal, or even nails is delivered in a box. There are many websites that show working manufacturing systems -- visit some of these to see how different systems work! For example Jelly Belly jellybeans are poured into a hopper during their manufacturing process. The hopper feeds them into a scale system which weighs and dispenses the precise amount of jellybeans into different types of packaging including bags, boxes, and jars.

- Jelly Belly Virtual Factory Tour (www.jellybelly.com/Virtual_Tour/virtual_tour.aspx)
- Hershey Chocolate Virtual Factory Tour (www.hersheys.com/discover/tour_video.asp)
- Tootsie Roll Industries Virtual Factory Tour (www.tootsie.com/gal_tour.php)

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Student Worksheet: You are the Engineer!

You are a team of manufacturing engineers who have been given the challenge of designing and then building a manufacturing system to deliver a consistent weight or count of marbles or other items to a series of four boxes or jars.

◆ Research/Preparation Phase

1. Review the Student Reference Sheet. If possible visit some of the virtual manufacturing websites.

◆ Planning as a Team

2. Your team has been provided with some materials by your teacher including wooden dowels, plastic bowls or paper cups, wire, tape, string, four canning jars or small empty boxes. You also have a large quantity of a "product" which may be marbles, paperclips, or other items your teacher has selected. Your job is to design a manufacturing system that will weigh a set amount of the product and deliver it to four jars or boxes. You need to make sure the weight or count is on target, and that it is consistent between those four packages.

3. Start by meeting with your team and agreeing on a system design. Be creative and enjoy the process!

4. Estimate the count variance you expect will result between the four jars/boxes using your manufacturing system. What is the allowable or expected difference in weight or count between those four packages?

5. Write or draw your plan in the box below (or on a separate piece of paper).

A Question of Balance

Student Worksheet: Evaluation

◆ Construction Phase

5. Construct your manufacturing system.

6. Take a look at the systems created by other class teams.

7. Run your system and "package" four products. Your teacher will weigh each package for your team so you can see how well your system worked.

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

◆ Use this worksheet to evaluate your team's results in the Build a Big Wheel lesson:

1. Did you succeed in creating a manufacturing system? If not, why did it fail?

2. Did you have to make changes from your written design when you were actually building the system? If so, what part of the system required the most changes in the construction phase?

3. Do you think that working engineers have to adapt their original plans during the manufacturing process? Why might they?

4. How did the actual weight or count between the four "packages" vary? How did this result compare to your preproduction estimate?

5. What part of this process did you enjoy the most? Why?

6. What idea that you saw implemented in another team's work did you find most inventive? Why?

7. Did you find that there were many designs in your classroom that met the project goal? What does this tell you about engineering plans?

8. Did you find that working as a team made this project more successful? If not, why not? If so, explain.

9. In a real manufacturing environment, do you think the design of the "package" -- the box, jar, or bag -- is developed before, after, or at the same time that the product is developed? What would make most sense to you? Why?

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For Teachers: Alignment to Curriculum Frameworks

Note: All lesson plans in this series are aligned to the National Science Education Standards which were produced by the National Research Council and endorsed by the National Science Teachers Association, and if applicable, also to the International Technology Education Association's Standards for Technological Literacy or the National Council of Teachers of Mathematics' Principles and Standards for School Mathematics.

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

CONTENT STANDARD A: Science as Inquiry
As a result of activities, all students should develop
- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

CONTENT STANDARD B: Physical Science
As a result of their activities, all students should develop an understanding of
- Motions and forces

CONTENT STANDARD E: Science and Technology
As a result of activities in grades 5-8, all students should develop
- Abilities of technological design
- Understandings about science and technology

CONTENT STANDARD F: Science in Personal and Social Perspectives
As a result of activities, all students should develop understanding of
- Science and technology in society

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

CONTENT STANDARD A: Science as Inquiry
As a result of activities, all students should develop
- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

CONTENT STANDARD B: Physical Science
As a result of their activities, all students should develop understanding of
- Motions and forces

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 F: Science in Personal and Social Perspectives
As a result of activities, all students should develop understanding of
- Science and technology in local, national, and global challenges

◆Standards for Technological Literacy - All Ages

The Nature of Technology

- Standard 1: Students will develop an understanding of the characteristics and scope of technology.
- Standard 2: Students will develop an understanding of the core concepts of technology.
- Standard 3: Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

Design

- Standard 9: Students will develop an understanding of engineering design.
- Standard 10: Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Abilities for a Technological World

- Standard 12: Students will develop abilities to use and maintain technological products and systems.
- Standard 13: Students will develop abilities to assess the impact of products and systems.

The Designed World

- Standard 19: Students will develop an understanding of and be able to select and use manufacturing technologies.