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

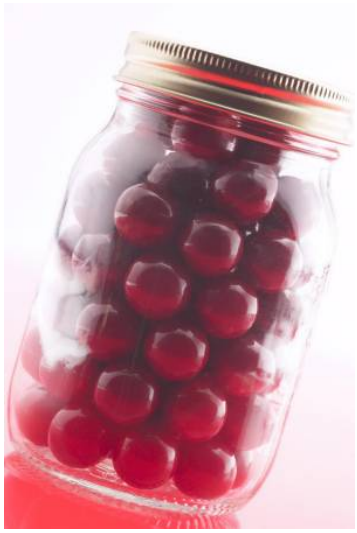
A Question of Balance explores how engineers use scales and measures when designing a manufacturing process to ensure that final products are uniform in weight or count. Students explore different types of scales, and are challenged to design and build a system to deliver a uniform count or weight of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

Year Levels

Year 5 – 10 Science Inquiry Skills and Science as a Human Endeavour

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

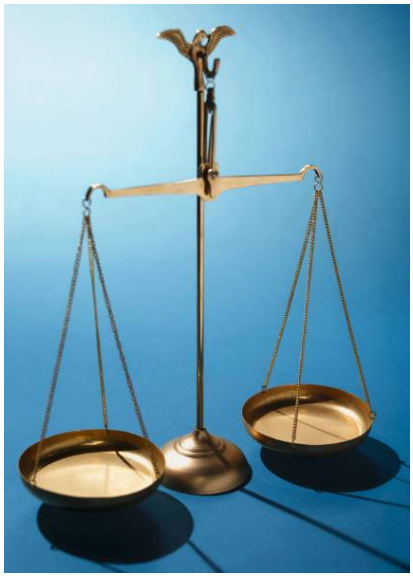
- Teacher Resource Documents (attached)
- Student Worksheets (attached)
- Student Resource Sheets (attached)

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)
- Curriculum Links (www.acara.edu.au)



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 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 lollies are 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

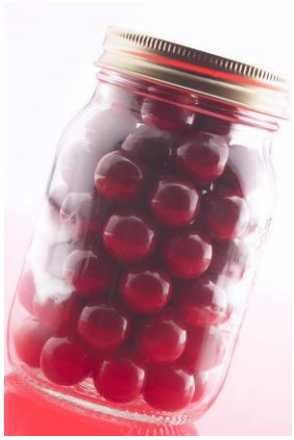
version…students may want to develop ramps or conveyor belts, tipping mechanisms, or other methods to deliver the lollies to the final package.

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

A Question of Balance

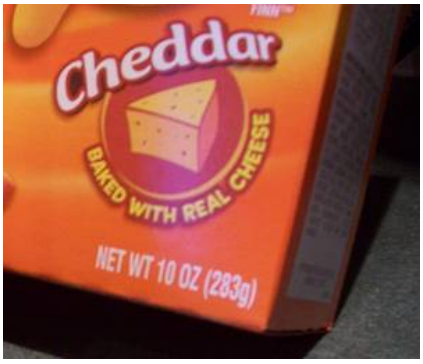
Student Resource:
Scale Applications

◆ 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 lollies, 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)

A Question of Balance

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 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

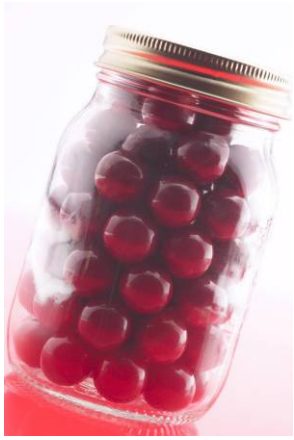
◆ Construction Phase

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 Question of Balance 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?

Student Worksheet: Evaluation (continued)

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?

A Question of Balance

For Teachers: Alignment to Curriculum Frameworks

Note: All lesson plans in this series are aligned to the Australian Curriculum for both Science.

Science Inquiry Skills

Year 5

With guidance, select appropriate investigation methods to answer questions or solve problems. (**ACSIS086**)

Use equipment and materials safely, identifying potential risks (**ACSIS088**)

Suggest improvements to the methods used to investigate a question or solve a problem (**ACSIS091**)

Year 6

With guidance, select appropriate investigation methods to answer questions or solve problems. (**ACSIS103**)

Use equipment and materials safely, identifying potential risks (**ACSIS105**)

Suggest improvements to the methods used to investigate a question or solve a problem (**ACSIS108**)

Year 7

Collaboratively and individually plan and conduct a range of investigation types including fieldwork and experiments, ensuring safety and ethical guidelines are followed (**ACSIS125**)

In fair tests, measure and control variables, and select equipment to collect data with accuracy appropriate to the task **(ACSIS126)**

Reflect on the method used to investigate a question or solve a problem, including evaluating the quality of data collected, and identify improvements to the method **(ACSIS131)**

Year 8

Collaboratively and individually plan and conduct a range of investigation types including fieldwork and experiments, ensuring safety and ethical guidelines are followed (**ACSIS140**)

In fair tests, measure and control variables, and select equipment to collect data with accuracy appropriate to the task **(ACSIS141)**

Reflect on the method used to investigate a question or solve a problem, including evaluating the quality of data collected, and identify improvements to the method **(ACSIS146)**

Year 9

Plan, select and use appropriate investigation methods, including fieldwork and laboratory experimentation, to collect reliable data; assess risk and address ethical issues associated with these methods **(ACSIS165)**

Select and use appropriate equipment, including digital technologies, to systematically and accurately collect and record data **(ACSIS166)**

Evaluate conclusions, including identifying sources of uncertainty and possible alternative explanations, and describe specific ways to improve the quality of the data **(ACSIS171)**

Year 10

Plan, select and use appropriate investigation methods, including fieldwork and laboratory experimentation, to collect reliable data; assess risk and address ethical issues associated with these methods **(ACSIS199)**

Select and use appropriate equipment, including digital technologies, to systematically and accurately collect and record data **(ACSIS200)**

Evaluate conclusions, including identifying sources of uncertainty and possible alternative explanations, and describe specific ways to improve the quality of the data **(ACSIS205)**

Science as a Human Endeavour

Year 5

Science involves testing predictions by gathering data and using evidence to develop explanations of events and phenomena **(ACSHE081)**

Scientific understandings, discoveries and inventions are used to solve problems and directly affect people's lives **(ACSHE083)**

Year 6

Science involves testing predictions by gathering data and using evidence to develop explanations of events and phenomena **(ACSHE098)**

Scientific understandings, discoveries and inventions are used to solve problems and directly affect people's lives **(ACSHE100)**

Year 7

Science knowledge can develop through collaboration and connecting ideas across the disciplines of science **(ACSHE223)**

People use understanding and skills from across the disciplines of science in their occupations **(ACSHE224)**

Year 8

Science knowledge can develop through collaboration and connecting ideas across the disciplines of science **(ACSHE226)**

People use understanding and skills from across the disciplines of science in their occupations **(ACSHE227)**

Year 9

Advances in scientific understanding often rely on developments in technology and technological advances are often linked to scientific discoveries **(ACSHE158)**

Advances in science and emerging sciences and technologies can significantly affect people's lives, including generating new career opportunities **(ACSHE161)**

Year 10

Advances in scientific understanding often rely on developments in technology and technological advances are often linked to scientific discoveries **(ACSHE192)**

Advances in science and emerging sciences and technologies can significantly affect people's lives, including generating new career opportunities **(ACSHE195)**

Mathematics Links with Science Curriculum (Skills used in this activity)	General Capabilities	Cross-Curriculum Priorities
• Process data using simple tables • Data analysis skills (graphs) • Analysis of patterns and trends • Use of metric units	• Literacy • Numeracy • Critical and creative thinking • Personal and social capacity • ICT capability	• Sustainability

Science Achievement Standards

Year 5

By the end of Year 5, students classify substances according to their observable properties and behaviours. They explain everyday phenomena associated with the transfer of light. They describe the key features of our solar system. They analyse how the form of living things enables them to function in their environments. Students discuss how scientific developments have affected people's lives and how science knowledge develops from many people's contributions.

Students follow instructions to pose questions for investigation, predict what might happen when variables are changed, and plan investigation methods. They use equipment in ways that are safe and improve the accuracy of their observations. Students construct tables and graphs to organise and identify patterns. They use patterns in their data to suggest explanations and refer to data when they report their findings. They describe ways to improve the fairness of their methods and communicate their ideas, methods and findings using a range of texts.

Year 6

By the end of Year 6, students compare and classify different types of observable changes in materials. They analyse requirements for the transfer of electricity and describe how energy can be transformed from one form to another to generate electricity. They explain how natural events cause rapid changes to the Earth's surface. They decide and predict the effect of environmental changes on individual living things. Students explain how scientific knowledge is used in decision making and identify contributions to the development of science by people from a range of cultures.

Students follow procedures to develop investigable questions and design investigations into simple cause-and-effect relationships. They identify variables to be changed and measured and describe potential safety risks when planning methods. They collect, organise and interpret their data, identifying where improvements to their methods or research could improve the data. They describe and analyse relationships in data using graphic representations and construct multi-modal texts to communicate ideas, methods and findings.

Year 7

By the end of Year 7, students describe techniques to separate pure substances from mixtures. They represent and predict the effects of unbalanced forces, including Earth's gravity, on motion. They explain how the relative positions of the Earth, sun and moon affect phenomena on Earth. They analyse how the sustainable use of resources depends on the way they are formed and cycled through Earth systems. They predict the effect of environmental changes on feeding relationships and classify and organise diverse organisms based on observable differences. Students describe situations where scientific knowledge from different science disciplines has been used to solve a real-world problem. They explain how the solution was viewed by, and impacted on, different groups in society.

Students identify questions that can be investigated scientifically. ***They plan fair experimental methods, identify variables to be changed and measured. They select equipment that improves fairness and accuracy and describe how they considered safety. Students draw on evidence to support their conclusions***. They summarise data from different sources, describe trends and refer to the quality of their data when suggesting improvements to their methods. They communicate their ideas, methods and findings using scientific language and appropriate representations.

Year 8

By the end of Year 8, students compare physical and chemical changes and use the particle model to explain and predict the properties and behaviours of substances. They identify different forms of energy and describe how energy transfers and transformations cause change in simple systems. They compare processes of rock formation, including the time scales involved. They analyse the relationship between structure and function at cell, organ and body system levels. Students examine the different science knowledge used in occupations. They explain how evidence has led to an improved understanding of a scientific idea and describe situations in which scientists collaborate to generate solutions to contemporary problems.

Students identify and construct questions and problems that they can investigate scientifically. ***They consider safety and ethics when planning investigations, including designing field or experimental methods. They identify variables to be changed, measured and controlled***. Students construct representations of their data to reveal and analyse patterns and trends, and use these when justifying their conclusions. ***They explain how modifications to methods could improve the quality of their data and apply their own scientific knowledge and investigation findings to evaluate claims made by others***. They use appropriate language and representations to communicate science ideas, methods and findings in a range of texts types.

Year 9

By the end of Year 9, students explain chemical processes and natural radioactivity in terms of atoms and energy transfers and describe examples of important chemical reactions. They describe models of energy transfer and apply these to explain phenomena. They explain global features and events in terms of geological processes and timescales. They analyse how biological systems function and respond to external changes with reference to interdependencies, energy transfers and flows of matter. They describe social and technological factors that have influenced scientific developments and predict how future applications of science and technology may affect people's lives.

Students design questions that can be investigated using a range of inquiry skills. ***They design methods that include the control and accurate measurement of variables and systematic collection of data and describe how they considered ethics and safety. They analyse trend in data, identify relationships between variables and reveal inconsistencies in results. They analyse their methods and the quality of their data, and explain specific actions to improve the quality of their evidence***. They evaluate others 'methods and explanations from a scientific perspective and use appropriate language and representations when communicating their findings and ideas to specific audiences.

Year 10

By the end of Year 10, students analyse how the periodic table organises elements and use it to make predictions about the properties of elements. They explain how chemical reactions are used to produce particular products and how different factors influence the rate of reactions. They explain the concept of energy conservation and represent energy transfer and transformation within systems. They apply relationships between force,

mass and acceleration to predict changes in the motions of objects. Students describe and analyse interactions and cycles within and between Earth's spheres. They evaluate the evidence for scientific theories that explain the origin of the universe and the diversity of life on Earth. They explain the processes that underpin heredity and evolution. Students analyse how the models and theories they use have developed over time and discuss the factors that prompted their view.

Students develop questions and hypotheses and independently design and improve appropriate methods of investigation, including field work and laboratory experimentation. They explain how they have considered reliability, safety, fairness and ethical actions in their methods and identify where digital technologies can be used to enhance the quality of their data. When analysing data, selecting evidence and developing and justifying conclusions, they identify alternative explanations for findings and explain any sources of uncertainty. Students evaluate the validity and reliability of claims made in secondary sources with reference to currently held scientific views, the quality of methodology and the evidence cited. They construct evidence-based arguments and select appropriate representations and text types to communicate science ideas for specific purposes.