FANCY FEET ACTIVITY

PART 2: DESIGNING AND MAKING SHOES

Part 2 of *Fancy Feet* will build on the data investigations of Part 1. Before the students design and create their shoes they will be reminded to think back on what they found in the last lesson, such as the *typical* shoe size for their class, the *range* of shoe sizes, the favourite type of shoe and the materials they are made out of. As the students will be making one shoe each (two shoes per group), they will need to decide what shoe size, design and materials they will use.

Part 2 will engage the students in engineering practices including further exploring shoe materials, shoe designs, and their manufacture. They will consider what materials they might use based on their properties and purpose as well as on what most people like. Collectively, these aspects will link back to the statistical practices of researching, collecting, and analysing statistical data, and to the concepts of variation, typical, mode, prediction, and certainty. Cost factors (optimising product outcome on a given budget), planning, designing, constructing, testing, assessing, retesting and improving outcomes will comprise the major part of the activity.

Part 2 of the activity is split into 4 stages culminating in a Fancy Foot Parade.

This activity has been developed using aspects of the Teaching Engineering "Engineer a Sneaker" and "Fancy Feet" Activities as a base. These activities can be located at https://www.teachengineering.org/activities/view/engineer_a_sneaker and https://www.teachengineering.org/activities/view/cub_feet_activity1

OBJECTIVES

Students will:

1. Draw on their learning in part 1 to design and create a shoe of their choice;
2. Engage in engineering practices including recognising a design need (an engineering challenge or problem), explore shoe materials and shoe designs, and how they are manufactured;
3. Engage in engineering design processes including brainstorming ideas, planning, and designing (through initial sketching) possible shoe shapes and shoe features;
4. Select appropriate materials for creating their shoes;
5. Construct an initial model using a variety of supplied materials, taking into account given constraints;
6. Test, evaluate, and suggest ways to improve their product;
7. Link and consolidate their learning across the STEM disciplines including applying statistical and mathematical ideas from Part 1, scientific understandings (e.g., properties of materials, support, stability), and ideas from design and technology (engineering practices, design processes, technology in product generation).

Note: Part 2 of the activity builds on the learning achieved through the Primary Connections Material World unit http://www.scootle.edu.au/ec/viewing/S7160/material-world_2012/index.html and therefore should be undertaken post the unit's implementation.

THE AUSTRALIAN CURRICULUM CONTENT DESCRIPTORS YEAR 4 VERSION 8.2

PART 2

MATHEMATICS CURRICULUM

Number and Algebra - Money and Financial Mathematics
Solve problems involving purchases and the calculation of change to the nearest five cents with and without digital technologies (ACMNA080)
Measurement and Geometry - Using units of measurement
Use scaled instruments to measure and compare lengths, masses, capacities and temperatures (ACMMG084)
Measurement and Geometry
Using units of measurement:
Use scaled instruments to measure and compare lengths. (ACMMG084)
Shape:
Compare the areas of regular and irregular shapes by informal means (ACMMG087)

SCIENCE CURRICULUM

Chemical sciences
Natural and processed materials have a range of physical properties that can influence their use (ACSSU074)
Physical sciences
Forces can be exerted by one object on another through direct contact or from a distance (ACSSU076)
Science as a Human Endeavour - Nature and development of science
Science involves making predictions and describing patterns and relationships (ACSHE061)
Use and influence of science
Science knowledge helps people to understand the effect of their actions (ACSHE062)
Science Inquiry Skills - Questioning and predicting
With guidance, identify questions in familiar contexts that can be investigated scientifically and make predictions based on prior knowledge (ACSIS064)
Science Inquiry Skills - Planning and conducting
With guidance, plan and conduct scientific investigations to find answers to questions, considering the safe use of appropriate materials and equipment (ACSIS065)
Consider the elements of fair tests and use formal measurements and digital technologies as appropriate, to make and record observations accurately (ACSIS066)
Science Inquiry Skills - Evaluating
Reflect on investigations, including whether a test was fair or not (ACSIS069)
Science Inquiry Skills - Communicating
Represent and communicate observations, ideas and findings using formal and informal representations (ACSIS071)

TECHNOLOGIES CURRICULUM

Students explore and learn to harness their creative, innovative and imaginative ideas and approaches to achieve designed products, services and environments. They do this through planning and awareness of the characteristics and properties of materials and the use of tools and equipment. They learn to reflect on their actions to refine their working and develop their decision-making skills.

Using a range of technologies including a variety of graphical representation techniques to communicate, students clarify and present ideas, for example by drawing annotated diagrams; modelling objects as three-dimensional images from different views by visualising rotating images and using materials. Students recognise techniques for documenting design and production ideas such as basic drawing symbols, and use simple flow diagrams.

Design and Technologies Knowledge and Understanding
Recognise the role of people in design and technologies occupations and explore factors, including sustainability that impact on the design of products, services and environments to meet community needs (ACTDEK010)
Investigate how forces and the properties of materials affect the behaviour of a product or system (ACTDEK011)
Investigate the suitability of materials, systems, components, tools and equipment for a range of purposes (ACTDEK013)

Design and Technologies Processes and Production Skills
Critique needs or opportunities for designing and explore and test a variety of materials, components, tools and equipment and the techniques needed to produce designed solutions (ACTDEP014)
Generate, develop, and communicate design ideas and decisions using appropriate technical terms and graphical representation techniques (ACTDEP015)
Select and use materials, components, tools, equipment and techniques and use safe work practices to make designed solutions (ACTDEP016)
Evaluate design ideas, processes and solutions based on criteria for success developed with guidance and including care for the environment (ACTDEP017)
Plan a sequence of production steps when making designed solutions individually and collaboratively (ACTDEP018)

MATERIALS LIST

PART 2

- Shoes and their materials table
- Engineering Alphabet Chart
- Shoes of Prey Media Release https://www.shoesofprey.com/content/media-release
- Shoes of Prey Introductory video clip https://www.youtube.com/watch?V=Lz_emedmuuc (3mins 6 secs).
- How shoes are made video clip www.shoesofprey.com/content/bespoke (6mins 47secs)
- Engineering Design Model diagram
- Student Workbooks
- Lab coats
- Assorted materials for making shoes
- Low temp glue guns and power boards
- Student owned scissors and rulers

Background information appears in the Appendix

Blank page

STAGE 1

Introduction

Have students think about what they learnt in our lesson last term when we explored our feet and shoes. Ask students to recall the following:

- What was the **most popular** favourite type of shoe for students in our class? (4B Sneakers, 4R Boots) What terms could we use to describe "most popular"?
- What was the **typical** material our favourite shoes are made from? (4B and 4R Leather)
- What was the **mode** for the shoe sizes in our class? (4B Size 3, 4R Size 4)
- What was the **range** of foot length in our class? (4B 18-25cm, 4R 20 – 26cm)

Introduce a discussion on parts of a shoe (sole, upper, laces, etc.) by asking students to remove their shoe and identify each part.

Ask students what would happen if you wore flippers in a running race. Reach a consensus that different shoes have different purposes, and shoes/materials chosen have to be the right materials for the purpose of the shoe.

Material Exploration

Reflect on materials and properties from the *Primary Connections Material World Unit* by asking students to define what we mean by "material." (What something is made out of, e.g., a raincoat is made out of plastic.)

Similarly, ask students to define the term "properties". (The qualities, the attributes of an object, e.g., the plastic raincoat is "light", "windproof" and most importantly "waterproof").

Ask students to think about the materials used in the shoes they are wearing today and ask if they are all the same. (No, it is likely that the upper is made from leather, the sole is made from rubber and the laces are made from fabric/cotton/nylon. If a running shoe, the sole is probably made from rubber, the upper made from fabric and the laces are made from fabric/cotton/nylon). Ask students to describe the *variation* in the materials used. Ask students to explain why there is variation in the materials used. (Different materials have different properties and therefore serve different purposes.)

If not raised by students, confirm that different types of shoes also have different materials based on their different designs and purposes.

Ask students to list properties of some shoe materials and their purpose, for example ugg boots/slippers are made from lamb's wool and are heat insulating, gum boots are made from plastic and are waterproof, runners are made from fabric and are lightweight and flexible, etc.

Display the following table on the whiteboard. Ask students to help you complete the table.

SHOES AND THEIR MATERIALS

Purpose	Type of footwear	Material or materials it is made from	Synthetic (man-made) or natural	Property of material that achieves its purpose
Keep your feet warm				
Keep your feet dry				
Keep your feet cool				
Protect your feet from sharp objects				
Help you to swim faster				
Help you to run faster				
Enable you to skate on ice				
Make you taller				

Shoe design

Introduce the shoe design activity by explaining that most of the time we put on our shoes without thinking about who designed the shoe and why a particular design was created. Inform students that many engineers are involved in developing new shoe styles and improving existing designs. Shoe engineers design, build and test shoes before they reach the shops to be sold to you. Engineers are always looking for ways to improve the quality of people's lives. And they do!

Hand out the Engineering Alphabet Chart to each group. Ask students to identify the types of engineers who could be involved in shoe design.

- *Chemical Engineers* transform raw materials into products we use every day;
- *Material Engineers* work with existing materials to make them into useful products;
- *Industrial Engineers* organise the materials, machines, information and people to ensure that an industrial production process functions smoothly,
- *Manufacturing Engineers* work with all aspects of manufacturing processes, including automation, production control and materials handling;
- *Mechanical Engineers* design and develop machines and they influence the design of other products as well, such as shoes, light bulbs and even doors;
- *Computer/Software Engineers* have created 3D Printers that are now being used to make running shoes.)

Our task

Inform students that today they will work as engineers to solve a problem, they will create, build, test and redesign their own pair of shoes just like Jodie Fox, cofounder of Shoes of Prey. See Shoes of Prey Media Release for further background information. https://www.shoesofprey.com/content/media-release

Introduce Shoes of Prey as an example of someone identifying a problem and sourcing a solution. One of the company co-founders, Jodie Fox, identified a problem (she couldn't find the perfect shoes) and created an Australian start up company with cofounders Michael Fox and Mike Knapp. Both Michael and Mike worked for Google before joining with Jodie to start Shoes of Prey. Mike Knapp is a Software Engineer. Show video clip https://www.youtube.com/watch?v=Lz_EmeDmUUc (3mins 6 secs).

Inform students that we will now watch another video clip from Shoes of Prey that shows the process of designing and making a shoe. Ask students to look for the different steps in the process.

Play the video clip showing how shoes are made: www.shoesofprey.com/content/bespoke (6mins 47secs)

Briefly recap on the steps seen in the video, listing each on the whiteboard: draw a design, select materials, measure and cut materials, put together (assemble), check quality, redo if quality needs improving, pack, and send to customer. Explain that this process is similar to what engineers do when solving problems and creating products.

Engineering Design Model

Display the Engineering Design Model on the whiteboard and inform students that we are going to work through the model together by reflecting on the steps shown on the video. Start students off with the "problem" by explaining that engineers are great at solving problems/inventing solutions for a wide range of problems or needs.

First, engineers must clarify the **problem** to be solved, or what is needed.

Then, they **brainstorm** creative ideas on how they might solve the problem.

They may need to **experiment** with materials before moving to the next step.

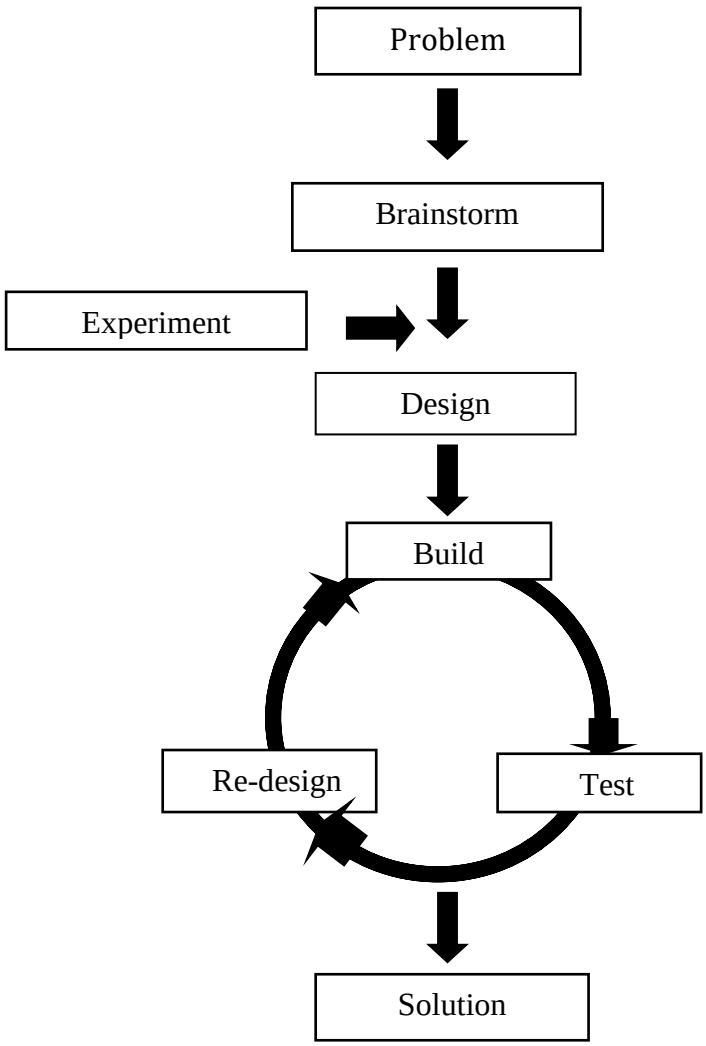
Next, they analyse those ideas and select the most promising one, and draw or communicate the **design** plan for the idea.

Then, they **build** a prototype or model of the design and evaluate whether or not that design is successful, that is, does it solve the problem or create the desired product.

The design process continues, in a cyclical fashion, as engineers keep **testing** and **redesigning** the design to make it the best it can be.

They end with a finished product/**solution** to the problem.

ENGINEERING DESIGN MODEL



Model adapted from pbs.org model

Hand out Student Workbook for Part 2. Ask students to record their name, partner/s' names, class and group number on the front cover.

https://tikktok.wordpress.com/tag/weird-shoes/

FANCY FEET ACTIVITY WORKBOOK – PART 2

Name: _____

Other group members: _____

_____

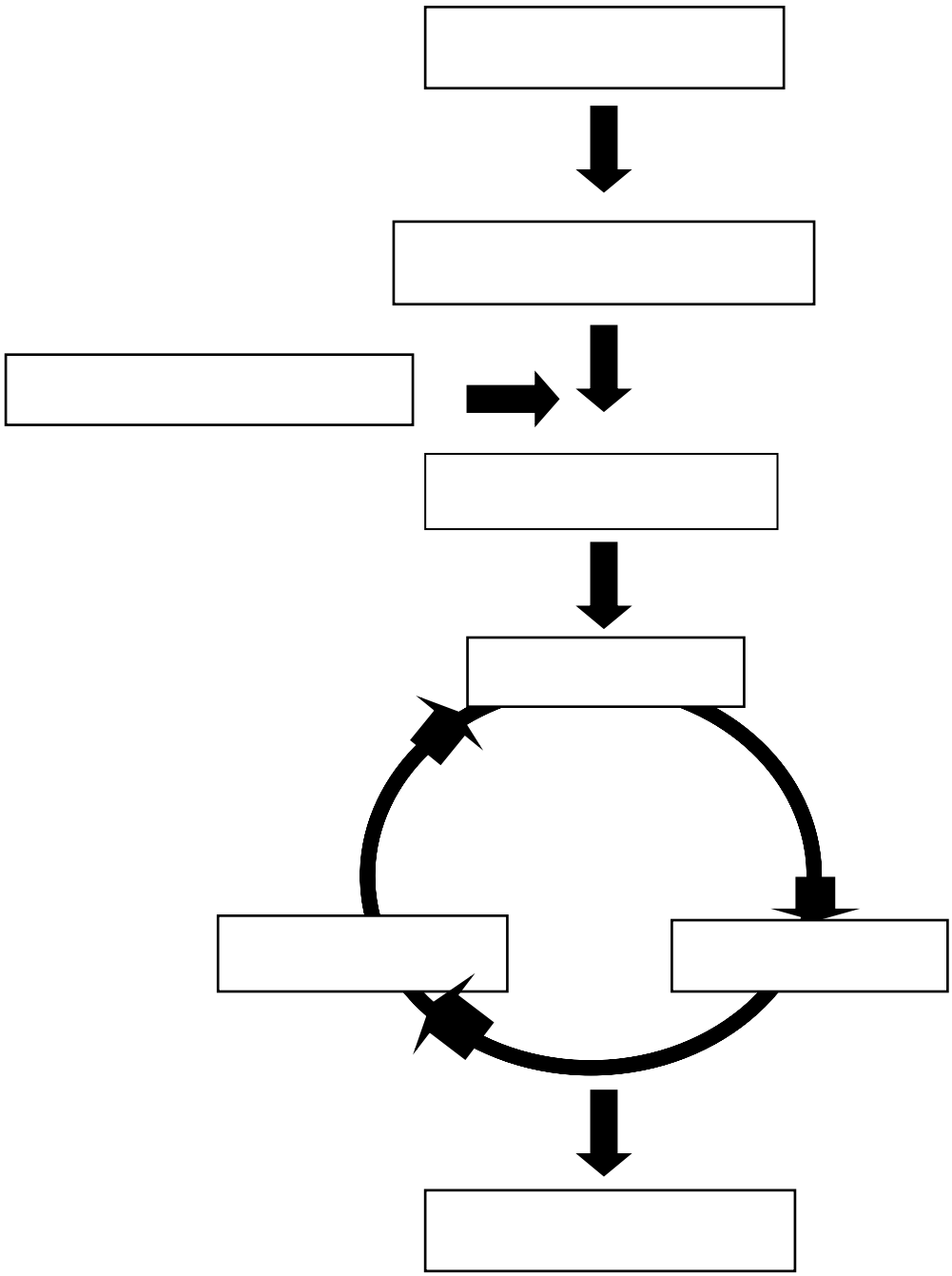
_____

_____

Group Number: _____ Class: _____

Ask students to turn to pg 2 of the Student Workbook and to copy the steps from the Engineering Design Model into their workbook model.

ENGINEERING DESIGN MODEL



Model adapted from pbs.org model

Engineering model and link to shoe design process

Using the completed Engineering Model, walk students through a summary of all pages of the Student Workbook before allowing them to start Stage 1 of the task. Advise students that you will discuss each step in more detail as they progress through the activity. Ask students to save their questions until each stage.

Remind students that engineers start with a ***problem*** or a need. Today each group will get to decide on a shoe problem or need and create a shoe that meets a need identified by their group. The design must be a group design. The overall problem/need will be recorded on pg 3 of the Student Workbook.

Inform students that the focus on shoe design will be about the purpose or activity that it will be used for; this activity can be real such as keeping your feet cool but protected in our hot summers, or imaginary/futuristic such as even walking on air. Students will record 3 aims for their shoe design on pg 3 of the Student Workbook.

Engineering steps for designing and making shoes.

1. What shoe problem/need has your group identified?

_____

_____

_____

_____

2. List 3 things that your group would like your shoe design to achieve.

Aim 1:_____

_____

Aim 2: _____

_____

Aim 3: _____

_____

Now that students have decided what their shoe design should achieve, they will need to consider how to test their shoe design against each of the 3 aims.

Inform students they will be creating and recording their own testing method and criteria for each of their aims on pg 4 of the Student Workbook.

Students need to consider what criteria they will use to determine how they will rate their design against each. Discuss the term "criteria" with students. Provide an example for students such as those used in the Liquorice Activity, that is the liquorice sticks students made were to be 8cm long and 1cm in diameter, these were the set criteria for that task. Ask students what test we could use to see if we had met those criteria. (Measure the length and diameter.) Inform students that if they made a liquorice stick that was exactly 8cm long and 1cm in diameter, they would rate their stick as high. If students made a liquorice stick close to the set criteria but not exactly the same, they would rate their liquorice stick a little lower. However, if they made a liquorice stick that was only 5cm long and it was 3cm in diameter, they would rate their liquorice stick as low as it didn't meet the criteria.

3. How will you test how well your design meets each of these aims?

Aim 1 Test:_____

_____

How will you know if it passes the test? _____

_____

_____

Aim 2 Test: _____

_____

How will you know if it passes the test? _____

_____

_____

Aim 3 Test: _____

_____

How will you know if it passes the test? _____

_____

_____

Groups will ***brainstorm*** their ideas for the design recording notes on pg 5 of the Student Workbook.

4. Brainstorm your design ideas with your group member/s. Use the space below to record some notes. You may sketch a rough draft if you like, however you will draw a detailed design later.

Remind students they have learnt a lot about materials and their properties and today we are going to put that knowledge to use when designing our shoes. Inform students that their challenge is to figure out how to create a shoe that they can wear from the materials available that will achieve their aims. Inform students that whilst we won't be using materials such as leather and rubber as they are too hard for students to safely cut/work with, we will be using materials that have similar properties.

Inform students they will be given a "cardboard sole" as the basis of their shoe. They will need to select the right size for their foot.

Ask students to turn to page 6 of the Student Workbook and to read the list of materials available. (sponge, fabric, sandpaper, bubblewrap, plastic – thin, plastic – thick, foam sheeting, non slip matting, cardboard, cottonballs, ribbon, string, velcro dots, glue).

Inform students that they may ***experiment*** with the materials before they create their ***design***.

In real life, engineers always work within limitations, such as the *materials available, a timeframe, and a budget*. Ask students to explain what a budget is. Inform students that engineers call these limitations "design constraints". Fortunately, as human beings, we can be innovative and resourceful. So, we would like you to be creative when designing your shoes!

Inform students that just as real engineers have to work with real budgets, they will have to do the same today. Inform students that all materials will have a price attached as per the table on pg 6 of the Student Workbook and that each group will have to work within the set budget of $10.

Likewise a time constraint of 45 minutes will be applied for the 1st design (brainstorming ideas, selecting materials, purchasing materials, completing the budget, drawing their design, and building their design).

Once students have brainstormed their ideas they are to complete the table on pg 6 of the Student Workbook as per the instructions at the top of the page.

5. Tick the materials in the 1st column below that your group has chosen to use.
Use the 2nd column in the table to record the property that the material has.
Complete the 3rd column by recording what part of the shoe you will use that material for.
Use the last column to add up the cost of your shoe.
Remember to keep to your budget of $10!

Material	Property	Part of shoe	Cost per item	Cost
cardboard sole			$1.50	
sponge			$1.75	
fabric			$1.25	
sandpaper			$2.00	
bubblewrap			$1.75	
plastic - thin			$1.00	
plastic - thick			$1.50	
foam sheeting			$1.25	
non slip matting			$2.00	
cardboard			$1.75	
cottonballs			4 for $2.00	
ribbon			$1.25	
string			$1.00	
velcro dots			2 for $2.00	
glue			$1.50	
			Total cost	

Explain that when students are designing their shoe, they will need to think about the qualities and features they would like their shoe to have including its *shape and the measurements needed for their feet, the materials they will use and their properties, and how well their shoe will achieve their 3 aims.*

Students will then draw their design on pg 7 of the Student Workbook, labelling each part of the shoe with the materials chosen and all measurements taken.

Once designs are drawn, students can begin to "build" their shoe. A safety warning about the low temperature glue guns to be used and the necessary power cords needs to be given.

Inform students that once one shoe is made, Stage 1 is concluded and we will have to wait until the materials have dried before we can move onto Stage 2.

Photos will be taken of the 1st design.

6. Use the space below to draw your group's design. Make sure you label your design indicating the materials you have chosen for each part of the shoe and *all* the measurements you have taken.

1st design

7. Now you can begin to build your shoe. Once it's built, we will need to allow time for the materials to dry.

STAGE 2 – TEST AND REDESIGN

Inform students that when the lesson resumes they will ***test*** their shoe and ***redesign*** it to make it better. Ask students how we would know if it was better. (The design achieves the aims, it rates higher on the scale of 1 to 5 for each aim.) The shoe made from the 2nd design will need to fit/be worn by the other group member.

Testing

Now that the materials have had time to dry, students can proceed to test their design.

Note: If not already done, photographs should be taken before testing begins.

Students need to consider their 3 design aims (recorded on pg 3 of Student Workbook) and their test/criteria (recorded on pg 4). Ask students why testing is important. (To identify any faults with the design so we can improve it.) Inform students that in order to do this properly, we need honest evaluation and fair testing.

One student should wear the shoe and all students in the group should rate the shoe on a scale of 1 to 5 based on their aims and its overall design, measurements and materials. Ratings are to be recorded on pgs 8 and 9 of the Student Workbook with students justifying their reasons for each on the lines provided.

Note: If students have discussed any of the criteria on pg 9 (i.e. design, measurements and materials) when addressing the criteria on pg 8 (i.e. their 3 aims) they can leave all/parts of pg 9 blank.

8. Use your testing criteria (recorded on pg 4) to test your 1st shoe design to determine if your design, measurements, and the materials chosen enabled you to meet your aims.

Circle the *rating* you would give your shoe for each of the following criteria and *record your reasons* for your rating on the lines below.

Aim 1	**1 (Low)**	**2**	**3**	**4**	**5 (High)**

_____

_____

Aim 2	**1**	**2**	**3**	**4**	**5**

_____

_____

Aim 3	**1**	**2**	**3**	**4**	**5**

_____

_____

Blank page

Keep going, remember 1 is low and 5 is high.

Design	**1 (Low)**	**2**	**3**	**4**	**5 (High)**

_____

_____

Measurements	**1**	**2**	**3**	**4**	**5**

_____

_____

Materials	**1**	**2**	**3**	**4**	**5**

_____

_____

Redesign

Students can now redesign their shoe in light of the testing conducted.

Inform students that the time constraint for the redesign and rebuild of the shoe is 30 minutes.

A new design is to be drawn on pg 10 of the Student Workbook with students indicating materials used, and how the changes will improve their design.

9. Think about your ratings above and how you could improve your shoe. Draw your new shoe design below. Ensure you label all parts of the shoe with the materials you have chosen for each part of the shoe and *all* the measurements you have taken. Record on your drawing how the changes will improve your design. Remember to keep to your $10 budget!

2nd design

Students will again have the choice of materials but must adhere to the budget of $10. Materials chosen, properties of each, which part of the shoe it will be used for and cost are to be recorded in the table on pg 11 of the Student Workbook.

Build

Students may now build their 2nd design and the lesson can continue when materials have dried thoroughly.

Remind students they need two shoes per group for the *Fancy Feet Parade* so they are not to destroy/use materials from their first design.

Each group will now have two shoes made. Photographs will be taken of their 2nd design and shoes will need to be stored in a safe place until Stage 3 can commence.

10. 2nd design

Material	Property	Part of shoe	Cost per item	Cost
cardboard sole			$1.50	
sponge			$1.75	
fabric			$1.25	
sandpaper			$2.00	
bubblewrap			$1.75	
plastic - thin			$1.00	
plastic - thick			$1.50	
foam sheeting			$1.25	
non slip matting			$2.00	
cardboard			$1.75	
cottonballs			4 for $2.00	
ribbon			$1.25	
string			$1.00	
velcro dots			2 for $2.00	
glue			$1.50	
			Total cost	

Build your second shoe. Remember not to destroy your first shoe.

Once it's built, we will need to allow time for the materials to dry.

STAGE 3 – TEST AND EVALUATE DESIGNS

Once ***built***, students' 2nd design will also photographed and then ***tested***.

2nd design testing

Once all groups have built their 2nd design, they can proceed to test and rate their design on pgs 12 and 13 of the Student Workbook. They use the same process as per testing and rating of their 1st design. Again, if pg 13 criteria have been discussed when addressing pg 12 criteria i.e. their 3 aims, all/parts of pg 13 can be left blank.

11. Test your 2nd shoe to determine if the design, your measurements, and the materials chosen enabled you to meet your aims.

Circle the *rating* you would give your shoe for each of the following criteria and *record your reasons* for your rating on the lines below.

Aim 1	**1 (Low)**	**2**	**3**	**4**	**5 (High)**

_____

_____

Aim 2	**1**	**2**	**3**	**4**	**5**

_____

_____

Aim 3	**1**	**2**	**3**	**4**	**5**

_____

_____

Blank page

Keep going, remember 1 is low and 5 is high.

Design	**1 (Low)**	**2**	**3**	**4**	**5 (High)**

_____

_____

Measurements	**1**	**2**	**3**	**4**	**5**

_____

_____

Materials	**1**	**2**	**3**	**4**	**5**

_____

_____

Evaluation

In preparation for the *Fancy Feet Parade*, students should record information about their designs on pg 14 and 15 of the Student Workbook. Ask students to record the aims of their shoe, list of materials used and why, how they tested their design, and an overall rating of their design. This information will help them "commentate" on one design while their partner models the design.

Note: Ensure one student records information on the 1st design and the other student records information on the 2nd design so that both designs are documented.

12. Complete the information below in preparation for the *Fancy Feet Parade*.

Shoe Design No. _____ (1 or 2?)

Aim 1: _____

_____

Aim 2: _____

_____

Aim 3: _____

_____

Materials used _____

_____

Why did you choose those materials? What properties did they provide?

_____

_____

_____

Blank page

How did you test your shoe design? _____

_____

_____

_____

_____

What overall rating would you give your shoe design and why?

_____

_____

_____

_____

_____

STAGE 4

Timing 2hrs

Fancy Feet Parade

Student A from each group will model shoe design 1 whilst Student B of the group commentates using the information students have recorded in the Student Workbook on pg 14 and 15. Student B will then model shoe design 2 whilst Student A repeats the above process and concludes by stating the improvements made in their redesign.

Time permitting, students can also discuss further changes they would make if they had more time.

Ideally students would be seated on the carpet along a "catwalk" so all students can see the shoe designs of the other groups.

Blank page

Wrap Up

Congratulate students on their designs and choice of materials.

Allow students time to complete the questions on pgs 16 and 17 of the Student Workbook.

13. Just a few final questions

How could you further *improve* your group's design?

_____

_____

_____

How does your pair of shoes *vary* from others that you have seen in the Fancy Feet Parade?

_____

_____

_____

What type of shoe was the *most popular* in the Fancy Feet Parade? Why do you think this was the most popular?

_____

_____

_____

Blank page

Do you think your shoes would be *typical* of those that the Year 4 students in Hobart might design and create? How might they *vary*?

Final class discussion

The activity can be concluded with a class discussion along the following lines:

1. How did the aims of the shoe design influence your choice of materials?
2. How did experimenting with the materials affect your design decisions and materials?
3. How did drawing your design help you think about the parts of the shoe?
4. What problems did you encounter when building your shoe?
5. How did testing and rating your shoe help you to improve your design?
6. Did you consider what we learnt in Part 1 (typical shoe size, favourite type of shoe, materials favourite shoes are made out of) when designing/creating your shoe? If not, how could that change your design?
7. What have you learnt about the engineering process of designing, creating, building, testing and redesigning a solution?

Blank page

APPENDIX of Background links/info

https://www.teachengineering.org/activities/view/cub_feet_activity1

Engineering Connection

Today, thousands of different types of shoes exist in our world and just as many engineers are working to develop new styles and improve existing designs. Engineers consider many variables when designing shoes—material type for durability and function, anticipated shoe stresses and strains, the health and safety of the shoe wearer, and the shoe's aesthetics. Engineers often work with podiatrists to design high-tech shoes that are safe, comfortable and stylish! Mechanical engineers apply principles of physics to analyze, design and manufacture mechanical systems, including new shoes. Materials engineers—specialists in the structure of materials and their properties—select and design the best combinations of materials for specific shoe purposes.

Background Information

As simple as a shoe might seem, it is actually a complex structure requiring a significant amount of engineering. Basically, a shoe is a system comprised of different parts that are sewn, stuck or welded together before being shaped and attached to a sole. In today's world, thousands of different shoe designs exist and just as many engineers are developing new shoes and improving existing designs. When designing shoes, engineers consider all sorts of variables: *suitable materials, anticipated forces the shoe will encounter, shoe wearer's health and safety, as well as aesthetics* (how it looks). Often, engineers work with podiatrists and kinesiologists (specialists in human movement) to design safe and comfortable shoes, and with fashion designers to create stylish and marketable products.

Materials: For centuries, leather has been the primary material for shoes. However, due to the work of many engineers (especially materials and chemical engineers), we now fabricate shoes using synthetic (human-made) materials. Leather is still preferred by some shoe-wearers due to its comfort and durability. A limitation of leather is that it cannot be obtained in endless rolls, which makes it less suitable for factory production in the footwear, glove and upholstery industries. Also, the material properties of leather tend to change in different conditions, and it is susceptible to fungal infections.

The main types of synthetic shoe soles that have been developed include materials based on ethylene vinyl acetate (EVA) and thermoplastic rubber. For the upper part of the shoe, polyurethane-coated fabric is a popular synthetic material. Polyurethane is a type of polymer that has many uses. It is commonly used as foam insulation in refrigerators and walls, packaging materials and upholstery. In the case of shoes, a very thin coating of polyurethane is applied to a cotton base. Polyurethane-coated fabrics have become increasingly popular because the surface creases closely simulate the 'break' or folding characteristics of leather. Also, its moisture absorption and permeability properties mimic natural leather. Polyurethane is water resistant yet breathable enough to discourage stinky feet!

Engineering for Stress and Strain: Just like civil engineers who design bridges, a "shoe engineer" must design shoes to withstand the different forces and conditions the shoes will be exposed to during their lifetimes. A typical pair of shoes is subjected to stress exerted by the wearer during normal use. In mechanical terms, stress is defined as the amount of force per

unit area. For example, for a 160-pound person jogging in a pair of shoes with a sole area (surface area that touches the ground) of 20 square inches, the runner exerts a stress of 160 pounds per 20 square inches (in2) = 8.0 psi (pounds per square inch).

A jogger exerts a compressive stress on the shoe. Compressive stress results in a material's compaction (decrease in volume). The runner also exerts a strain on the shoe by stretching the material when running. Over time, too much strain causes shoe material to break or rip (engineers call this "material failure.")

Some shoe styles, especially high heels and platforms, cause unnecessary stresses on various foot bones and joints. Over the past few decades, engineers have designed more comfortable and safe shoes while still maintaining desirable characteristics such as style, durability and affordability.

High Heels: Heeled shoes raise the heel of the wearer's foot higher than the toes. While many types of women's high-heel shoes exist, many other shoe designs have heels and are worn by both men and women, such as cowboy boots.

Some people love the look of high heels but cannot tolerate the discomfort! Standard construction of high-heel shoes creates a "ramp effect," in which the foot slants forward and down while bending the toes up. When the foot shifts forward, more weight is transferred to the ball of the foot, which can cause damage to the underlying soft tissue that supports the foot. In many high-heeled shoes, the toes become compressed, causing blisters, corns, hammer toes and bunions. Also, because high heels tip the foot forward, they put pressure on the lower back by pushing the derriere outwards and compressing the vertebrae. Many doctors advise wearing high heels as infrequently as possible and never more than 12 hours in a day.

Medical issues are certainly a hindrance to those who love to wear high heels! Recognizing that fashion trends are rarely influenced by health concerns, podiatrists and engineers have designed fashionable heels that do much less damage to the foot. Nike, a pervasive vendor of athletic shoes, apparel and sports equipment, developed an "air pump technology" that counterbalances the painful pressure caused by typical high heels by shifting the wearer's weight off the ball of the foot and back to the heel. The Nike air pump is an air bag system that uses pressurized air and a special wood pulp cellulose fiber. Because it is constructed within the shoe, placed under the ball of the foot and in the heel, these high heels look no different than conventional heels!

Platform Shoes: In contrast to high-heeled shoes, platform shoes raise both the toe and the heel equal amounts. Platform shoes are shoes, boots or sandals with thick soles, usually made of wood, cork, plastic or rubber. Because the toe and heel remain at about same level in platform shoes, wearers are less likely to suffer from the "ramp-effect" caused by high-heeled shoes. Still, platform shoes are best if designed with enough room for the toes to wiggle and a platform that is both rigid (to keep the wearer standing upright) and flexible (to absorb shock and permit some bend).

https://www.teachengineering.org/activities/view/engineer_a_sneaker

Engineering Connection

Biomedical engineers are involved in the design of sneakers. While it is important for sneakers to look stylish in order to appeal to consumers, they must also function properly. Many factors must be taken into consideration when designing sneakers, such as who will wear them (male, female, child) and for what types of activities. The end user and activity type indicate what shoe characteristics are most important for the design, such as traction, cushioning and/or height.

Background

Designing today's sneakers is an engineering science that combines physics, biomechanics and materials science. The engineering designs take advantage of a wide range materials and creative structural concepts to provide durability, comfort, cushioning and stability. Good designs also consider the characteristics of various foot types (female, male, child) since each has typical shapes and proportions. For example, women's feet are usually narrower with higher arches than men's feet. The inside layout of a well-designed sneaker takes these physical differences into account. Another important consideration is the activity application. Each sport has different footwear requirements; some require high flexibility, others maximum cushioning or high traction.

How shoes are made and designed: Traditional way of making shoes
https://www.youtube.com/watch?v=E-IcyDp3S1U

https://www.youtube.com/watch?v=LUE2pw4wGJ8 (this is a New Balance sneaker). The video has a good step-by-step commentary showing various forms of computer programming and machinery use through the process.

3D Printers explained

https://www.youtube.com/watch?v=Vx0Z6LplaMU (2min 21sec)

3D Printed shoes

https://www.youtube.com/watch?v=I6j9RyCgl7g (1min 22sec – not bad) or

https://www.youtube.com/watch?v=LUE2pw4wGJ8 (this is a New Balance sneaker) has good step by step commentary showing all sorts of computer programming and machinery through the process – 5mins)

Sustainability of materials used in shoes

https://www.theguardian.com/sustainable-business/sustainable-fashion-blog/2014/oct/09/footwear-industry-shoes-trainers-japan-shinto-temples

http://www.ecouterre.com/nike-now-makes-most-of-its-products-from-recycled-waste

Making Sandals in Sierra Leone: kaikai news
https://www.youtube.com/watch?v=H5vlkJfE_2A