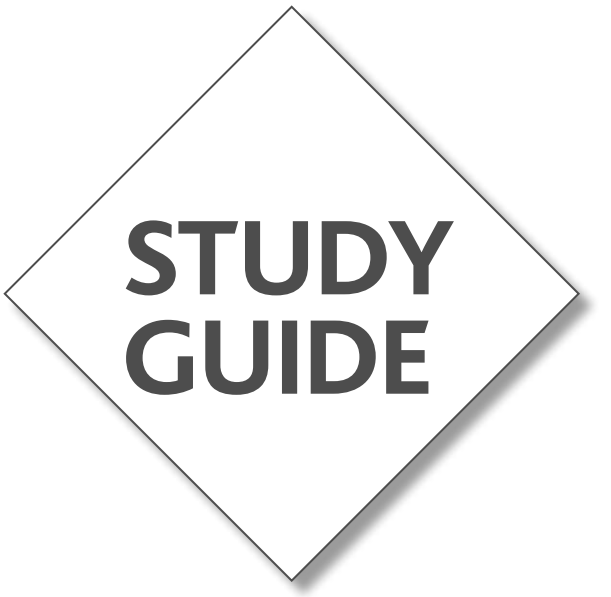


Design and Technology

Lower Secondary

Peter Stensel

HODDER EDUCATION
AN HACHETTE SINGAPORE COMPANY

Hachette Singapore's policy is to use papers that are natural, renewable and recyclable products and made from wood grown in well-managed forests and other controlled sources. The logging and manufacturing processes are expected to conform to the environmental regulations of the country of origin.

ISBN: 978 981 48 0166 9

© Peter Stensel 2021

First published in 2021 by

Hodder Education Singapore
An Hachette Singapore Company
52 Genting Lane
#06-05 Ruby Land Complex Block 1
Singapore 349560

www.hoddereducation.sg

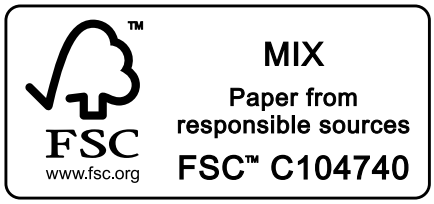
Impression number 10 9 8 7 6 5 4 3 2 1

Year 2025 2024 2023 2022 2021

All rights reserved. Apart from any use permitted under Singapore copyright law, no part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying and recording, or held within any information storage and retrieval system, without permission in writing from the publisher.

Typeset in Singapore

Printed in Singapore

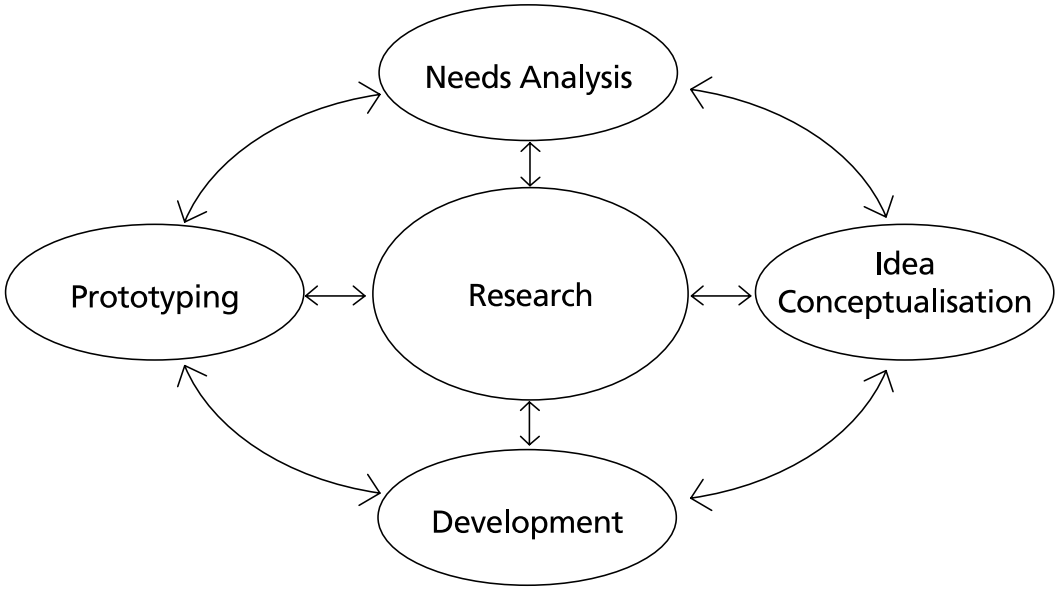


CONTENTS

1 THE DESIGN PROCESS

This chapter will help you to:

- *understand that design takes place in stages;*
- *understand the process used to work through the stages of design;*
- *gain awareness that design involves an ongoing dialogue between the designer and the user.*



Before you design something, you must first understand what it is that people really want or need. You must carry out some research to have a better understanding of the problem. Then, you can begin to draw and make models of some different solutions to meet the need or to solve the problem identified. With further research and discussions with people who would use your product, you will develop and improve your solution. Research, feedback and evaluation will be ongoing throughout the development of your idea, until you are finally ready to make your final solution.

This process of developing and making a product to meet a need is called the **design process** and is illustrated in the diagram above. As you can see from the arrows, it is not a linear process. There will be continual movement backwards and forwards between the different stages as the ideas develop, with each stage supported by further research.

If the design process is carried out correctly it will help to ensure that no part of the problem is overlooked and a successful solution is likely to be achieved.

Recording and responding to feedback from users is an important part of the design process.

Research

Undertaking useful and relevant research is an essential part of designing and making. Good research will support all stages of the design process, from analysing the needs to making the final prototype.

Some of the research tasks you may need to carry out include:

- observing and recording how people interact with products in the real world to help you identify design opportunities;
- creating an image board of visuals that will help to inspire and trigger ideas during the generation and development of a design;
- analysing products to gain a better understanding of design features;
- exploring, investigating and evaluating different technologies such as mechanisms, electronics and structures;
- gaining feedback about your ideas from potential users, which will help you refine your ideas;
- looking at different materials and construction methods to help you produce a successful prototype.

TASK

Explain the different types of research you would carry out if you were going to design and make the products listed below:

A toy for a baby

A board game for teenagers

A wheelchair for an elderly person with limited mobility

Needs Analysis

A good understanding of the users' needs is essential when designing a product and will help in the creation of a successful solution. Various methods can be used to help you identify needs in different situations and to then write a clear statement of the problem to be solved.

Some of the activities you may undertake as you investigate and clarify the users' needs include:

- preparing a questionnaire to gain responses from potential users;
- observing people and their interactions in different situations to identify design opportunities;
- creating quick sketches of ideas to help stimulate further opportunities;
- writing a clear statement explaining exactly what is needed and why it is needed. This is called the **design brief**;
- writing a list of requirements that must be satisfied as the solution is developed. This is called the **design specification**.

Image boards can be used to help focus the mind on the problem and to inspire ideas.

TASK

Identify some of the different needs for different users in the following situations:

School canteen

Public park

Idea Conceptualisation

Having thoroughly explored the needs of users and written your design brief, it will be time to start coming up with ideas to solve the problem. Generation of ideas may involve sketching, drawing and making mock-up models, thinking carefully about the user at all times.

You will need to be as imaginative and creative as possible, using different design tools to help you achieve a wide range of ideas.

Idea conceptualisation may include:

- use of ideation techniques such as SCAMPER or shape borrowing to inspire new ideas (see pages 40 to 42);
- ongoing consideration of the user, the function of the product and the environment;
- creation of mock-up models that can be used to obtain users' feedback;
- review of the design need, design brief and specifications;
- selection of a viable idea for further development.

DESIGN CHALLENGE

Choose one of the design needs you identified in the task on page 7. Sketch at least three different ideas for solving the problem.

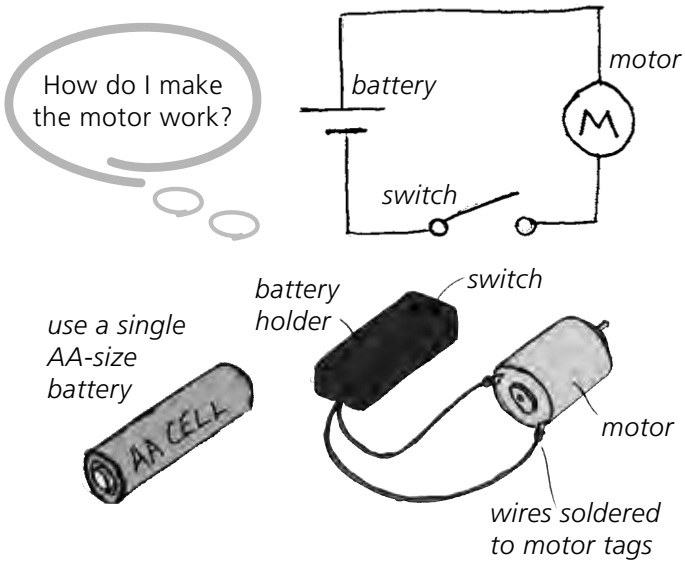
Design Need Identified: _____.

Development

The development stage of the design process involves working out the finer details of your design ideas. You will need to choose one or more of your initial ideas to develop through further drawings and models, taking into account feedback from your users. The development should result in a clear drawing of your final idea.

Development activities may include:

- exploring and refining the shape and form of the product to suit the user and the environment;
- investigating mechanisms or electronics using suitable kits;
- undertaking primary research to gain measurements of the body to ensure correct sizing of a design;
- making mock-up models to test part of a design;
- getting feedback from potential users;
- testing materials for strength and durability;
- preparing a working drawing and materials list to help with the manufacture of a prototype.



Developing the electrical workings of an idea

DESIGN CHALLENGE

Look at your design ideas on page 8. Select one of them and develop it in more detail in the space below. Annotate your drawings and add dimensions.

Prototyping

When the design idea has been developed in detail and a working drawing produced, it is time to make a final prototype of the product. A prototype is used to test and evaluate a design idea.

Making the prototype will involve working with a range of materials using different tools and processes. **Safety must be strictly observed at all times when working in a school workshop**.

During the prototyping stage you will:

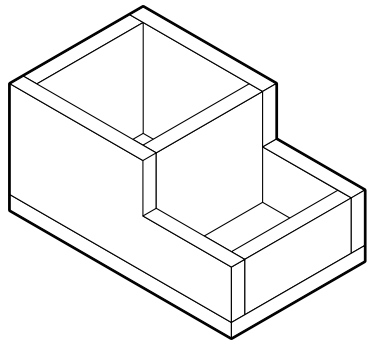
- develop your making skills by applying your knowledge of tools, materials and processes;
- explore alternative ways of making your product when your planned method fails;
- carry out experiments to check that mechanims and/or electronics will work as expected;
- ask users to test your prototype as part of your final evaluation.

QUESTION

While Thomas Edison was developing the electric light, he tried out over 1000 ideas that didn't work before he achieved a solution. What does this tell you about the importance of perseverance and resilience when designing and making something?

QUESTION

The drawing below shows a design idea for a small storage box.



1. Suggest a suitable material that could be used to make the box.

2. Which tools would you use to cut out the pieces for the box?

3. Explain how you would join the pieces of the box together. Include a sketch.

Evaluation and Feedback

Throughout the design process, you have to make decisions about your design ideas. In many cases, these decisions will be made after obtaining feedback from users and completing an evaluation.

Evaluation involves asking questions about an idea or solution to find out whether it works as expected. Through an evaluation, you find out the good and bad points about an idea. This information can then be used to decide how to proceed and how you can improve your solution.

EVALUATING YOUR FINAL SOLUTION

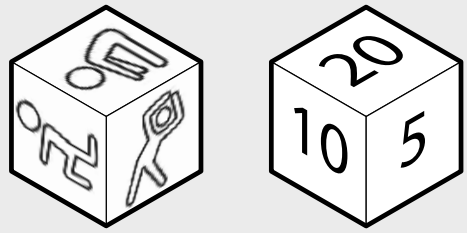
Evaluation measures the success of your design project in solving the problem identified at the beginning of the project. Here are some guidelines on how to carry out a final evaluation:

- compare your solution to the design specification;
- ask users to comment on your solution. Collate the data and present it in a table or graph.
- produce an evaluation report which includes:
  - written statements of how well the product matches the specification;
  - photographs showing how the tests are carried out;
  - problems that arose while making your prototype;
  - list of strengths and weaknesses of your solution.

- Reflect on the progress of your work as you design and make things.
- Evaluate your solution against your design specification.
- Identify ways to improve your solution.

QUESTION

A student was set a design brief to *design a low cost product for teenagers to encourage physical exercise*. The student's solution is shown below.



Rolling the dice determines the type of exercise and the number of times the exercise should be repeated.

What are the good points about this idea?

How would you improve the idea to add fun or make it more of a competitive challenge? Sketch your idea below.

DESIGN CHALLENGE

Design Brief
Design a product that will encourage families to spend more time together. The product should be affordable and suitable for manufacture in a school workshop.

Task 1
Research a range of products that encourage family time. List some of your findings below.

Task 2
What activities do your friends do with their families? Write down their answers below.

Task 3
What features do you think would be important for a product that encourages family time?

Task 4
Sketch two ideas of your own for a product to encourage more family time.

Idea 1

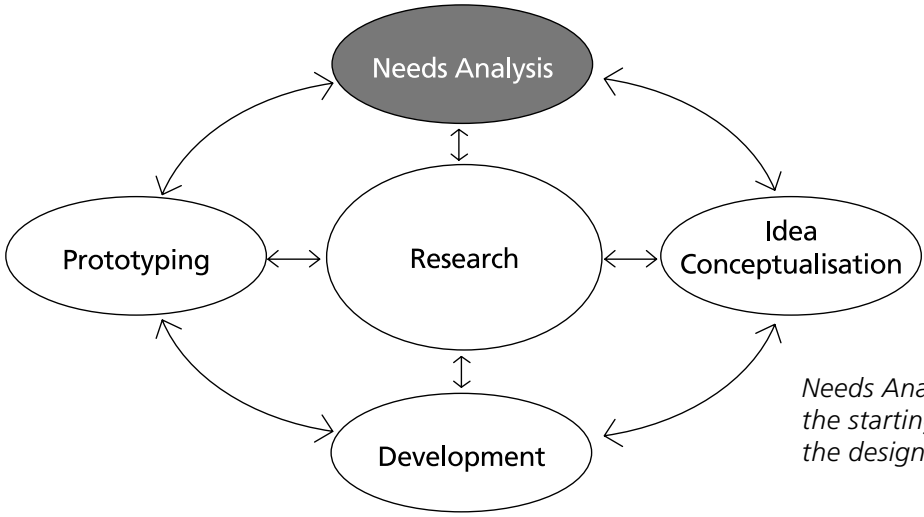
Idea 2

Task 5
Ask your friends and family to give you feedback on your ideas. What do they like about the ideas? What don't they like?

2 DEFINING A NEED

Analysing Design Situations

The starting point for your design project will be to gain a clear understanding of the design problem. What is the issue that needs to be solved? Who is affected by the problem? A design problem will usually be based around the needs of a particular group of **users** such as young children, travellers, shoppers or senior citizens.



Needs Analysis is the starting point of the design process

List some of the different groups of users you would see in the following places:		
School	Hospital	Museum

For some of your design projects in lower secondary you will be given a design problem to solve. The need will have been identified by your teacher and your challenge will be to design and develop a solution.

Sometimes you might be asked to identify a design need within a given situation. This chapter will guide you through the process of analysing and researching a design situation so that you can identify a need and have a thorough understanding of the problem to be solved.

Stating of design need, design brief and design specifications (5 marks)			
Pupils should be able to define design needs, design briefs and design specifications based on relevant research information.			
0 marks	1 mark	2 - 3 marks	4 - 5 marks
No design need, design brief and design specifications stated.	The design need, design brief and design specifications stated are unrelated, and/or unfocused.	The design need, design brief and design specifications stated are general and/or superficial.	The design need, design brief and design specifications stated are clear and concise.

All of the products that we buy or use each day have been designed to meet a need. What needs do the following products meet? For which groups of users have the products been designed?

	Toy	Games console	Pizza cutter
			
Users			
Needs			

OBSERVING SITUATIONS

One way to identify design needs is to simply observe a situation. Look around your school. What needs can you think of for different users? Some possibilities may include:

- *teachers needing to be able to store equipment quickly and safely;*
- *visitors needing clear signposts to help them find their way round the school;*
- *pupils needing comfortable, sturdy seats to sit on;*
- *canteen staff needing to be able to display and serve food hygienically.*

TASK

Visit one of the places listed below and spend some time observing the situation. Paste a photo of the situation below. Make a list of some of the things needed by different groups of people.

- *Travellers at an MRT station*
- *Shoppers at a mall*
- *Diners at a take-away restaurant*

Paste a photo of your chosen situation here

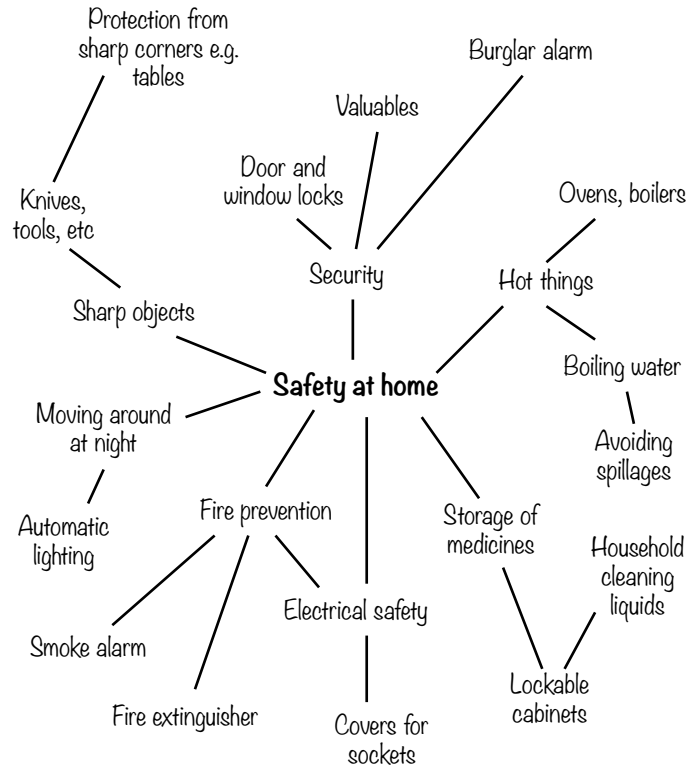
Needs I have identified:

MIND MAPPING A DESIGN SITUATION

Another way of identifying needs in a situation is to create a mindmap. Start by stating the situation in the centre of a page. The next step is to add words around the centre that relate to the situation. Lines are added to link words together. The example shows a mindmap exploring safety at home.

Having completed the mindmap in as much detail as possible, you can then use it to help you identify design needs. Some examples from the mindmap include:

- *A holder is needed for sharp kitchen knives to keep them safely in a drawer;*
- *An nightlight is needed that switches on automatically when it gets dark;*
- *Young children need to be protected from sharp corners on furniture in the home.*



TASK

Create a mindmap for a situation of your choice. Use your mindmap to identify three different design needs.

Design Need 1 _____

_____

Design Need 2 _____

_____

Design Need 3 _____

_____

5W1H METHOD

Sometimes it is helpful to explore a situation by asking questions. One way of doing this is to use the 5W1H method, in which each letter stands for a question:

What? Who? Why? When? Where? How?

The questions you ask will help you think about the situation in different ways. Consider the following example:

Situation: *People in Public Spaces*

What?

- *What different public spaces are there?*
- *What do people do in public spaces?*
- *What needs to be maintained?*
- *What requirements will people have?*
- *What problems arise in public spaces?*
- *What special facilities are needed or used?*
- *What happens if .....?*

Who?

- *Who uses public spaces?*
- *Who looks after public spaces?*
- *Who makes decisions about public spaces?*
- *Who needs help in public spaces?*
- *Who works in public spaces?*

Why?

- *Why are public spaces needed?*
- *Why do they look the way they do?*
- *Why are they so busy/quiet at different times?*
- *Why do people choose to go there?*
- *Why is it easy/difficult for people to find their way around a public space?*

When?

- *When do people visit the public space?*
- *When is the space very busy/quiet?*
- *When does the space open/close?*
- *When will future events take place?*
- *When is the public space cleaned?*

Where?

- *Where do people sit/eat/drink?*
- *Where do people enter/leave?*
- *Where are the litter bins?*
- *Where can people get help?*
- *Where are the focal points in the space?*

How?

- *How do people get there and get home?*
- *How is the space advertised?*
- *How is it protected/secured/kept safe?*
- *How is the space lit?*
- *How are visitors kept safe?*

TASK

Look at some of the questions highlighted on page 16 relating to people in public spaces. Can you identify three different design needs for people in public spaces? An example is provided for you.

Example: *Exercise equipment is needed to help people keep fit in public spaces.*

Design Need 1 _____

Design Need 2 _____

Design Need 3 _____

In the space below, sketch some ideas to meet one of the needs you have identified.

TASK

In the boxes below write down as many questions as you can for a design situation of your choice.

Design situation: _____

What?

Who?

Why?

When?

Where?

How?

Can you identify three different design needs for your chosen design situation?

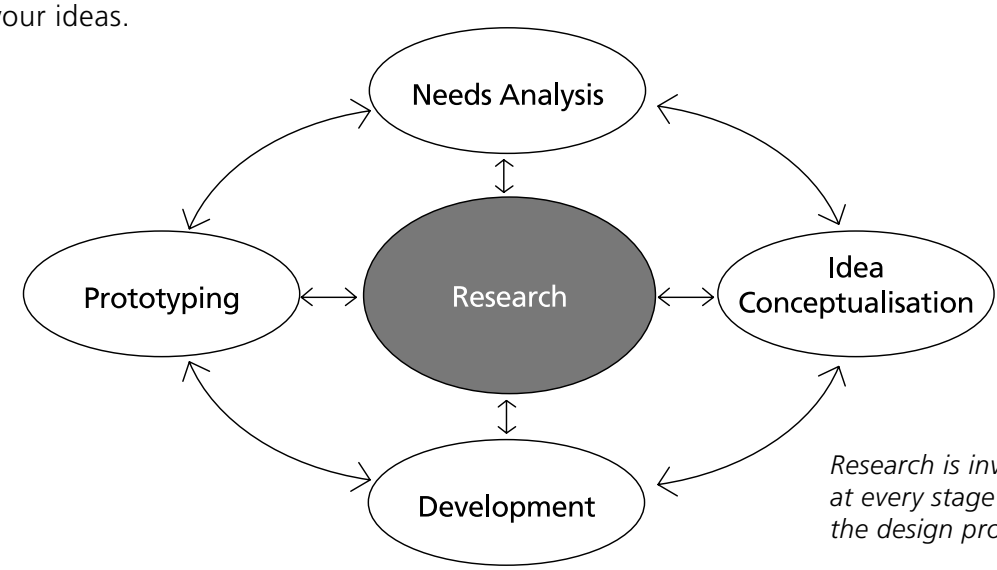
Design Need 1 _____

Design Need 2 _____

Design Need 3 _____

Research Methods

Good research is critical throughout the design process. The research you undertake will guide you in the right direction from the start of your project and will help you to make informed decisions as you develop and evaluate your ideas.



Research is involved at every stage of the design process.

As you undertake research you may need to:

- look at existing solutions to the problem and work out the good and bad features;
- find out what people would like to see in your design;
- find out about materials and technologies to use in your design;
- collect data that you will need, such as body measurements.

PRIMARY RESEARCH

Research you do yourself, such as visiting places, interviewing people or taking measurements, is called **primary research**. This research will be unique to you and to your design project.

SECONDARY RESEARCH

Some of your research may involve looking up information on the internet or using tables of data that already exist in the public domain. This is called **secondary research** because the information is already there - it is not unique to you and your project.

SOURCES OF INFORMATION

The type of information you will need to research will depend on the project you are undertaking. Some of the sources of information you can use include:

- ***The internet and social media*** *- use search engines to find out about products, news articles, costs and many other types of information. Social media can be used to quickly gain feedback from friends and family.*
- ***Books and magazines***
- ***On-site study*** *- visit a site/area to have a better understanding of the space.*
- ***Product analysis*** *- compare existing products in terms of how they look, the users they are aimed at, the materials they are made from, safety factors, environmental considerations, etc.*
- ***Observation and discussion*** *- talk to people such as experts, family or friends.*
- ***Disassembly*** *- take a product apart (if you can do it safely) to find out more about it.*
- ***Questionnaires*** *- design a questionnaire you can give to people to gather views and opinions of others.*

Identifying Your Target Market

Different products are designed for different groups of users. The group of users a product is aimed at is called the **target market**. Look at the products below. What can you say about the target market for each one?

Jar opener

Target Market: _____

_____

_____

Fitness tracker

Target Market: _____

_____

_____

Foldable seat

Target Market: _____

_____

_____

A target market may be based on age, interests, special needs, profession, and many other areas. The better you understand your target market the more likely it will be that you will design a product that meets their needs.

TASK

Use the space below to create an image board based on the target market for one of the products shown above.

Preparing and Using a Questionnaire

You will have lots of decisions to make during the design process. To help you make your decisions you can ask people within your target market to complete a **questionnaire**. You can then base your decisions on the responses you receive.

Make sure the questions you ask are *relevant* and will actually *be of help in your project*. The type of question you ask will determine the type of response. **Closed questions** provide pre-defined answers and are quick and easy to summarise. Responses to **open questions** will take longer to analyse because there are no pre-defined answers.

Yes/No Questions
These are basic closed questions with yes/no answers.
E.g.

Do you own a desktop computer?

☐ *Yes* ☐ *No*

Tick Box Questions
Some questions can have multiple responses.
E.g.

Which sports do you play?
Tick all that apply.

☐ *Hockey* ☐ *Tennis* ☐ *Football* ☐ *Basketball*

Multiple Choice Questions
Questions that require the respondent to select one option from a list are called multiple choice.
E.g.

How old are you?

☐ *Under 16 yrs* ☐ *16-24 yrs* ☐ *25+ yrs*

Rating Scale
Responses to rating scale questions can give an indication of feelings towards an issue.
E.g.

How would you rate this product?

☐ 0 ☐ *1* ☐ *2* ☐ *3* ☐ *4* ☐ *5*

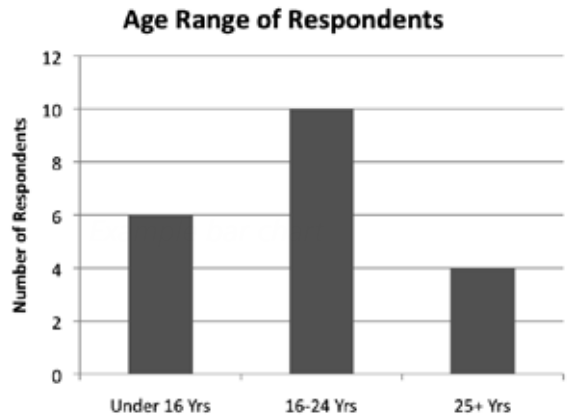
Open Ended Questions
With an open-ended question, responses will vary from one respondent to another.
E.g.

What do you think are the best features of this product?

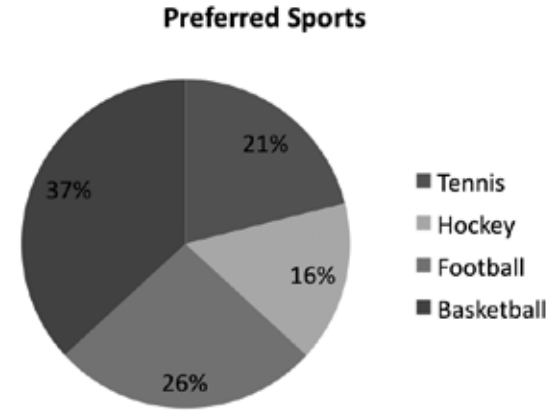
QUESTION
What are the advantages and disadvantages of asking closed questions in a questionnaire?

Presenting the Results of a Questionnaire

The results of a questionnaire must be presented in a clear way so that they are easily understood. Results are often presented using **bar charts** and **pie charts**.



Bar charts are useful for displaying exact values for different categories. A bar chart should have a title and clear labels on each axis.



Pie charts are useful for showing comparisons between different categories. A pie chart should have a title and the segments of a pie chart should be clearly labelled using a key.

TASK

The data below has been taken from a questionnaire about board games. Complete the charts to present the results of the questionnaire.

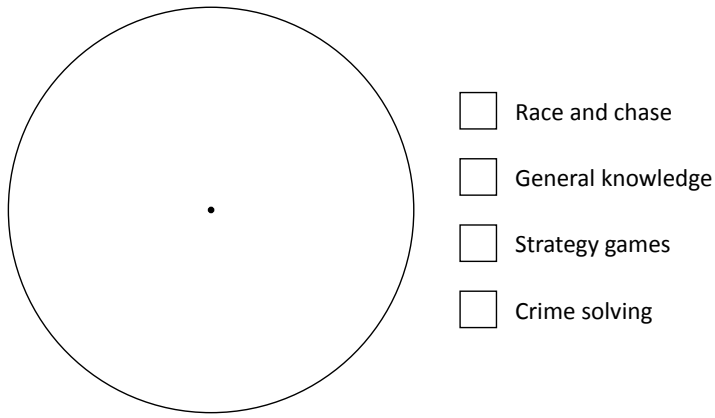
How often do you play board games?

Several times per week	*4*
Once per week	*8*
2-3 times per month	*10*
Once per month	*12*
Less than once per month	*7*
Never	*9*

Preferred choice of board game.

	Responses	*%*	*Angle*
Race and chase	*20*	*40*	*144°*
General knowledge	*10*	*20*	*72°*
Strategy games	*15*	*30*	*108°*
Crime solving	*5*	*10*	*36°*
TOTAL	*50*	*100*	*360°*

Preferred choice of board game



TASK

Prepare a questionnaire for your own project and gather as many responses as you can. In the space below, paste a thumbnail image of a completed questionnaire then present your results using bar charts and pie charts. Complete a summary of your findings.

Summary

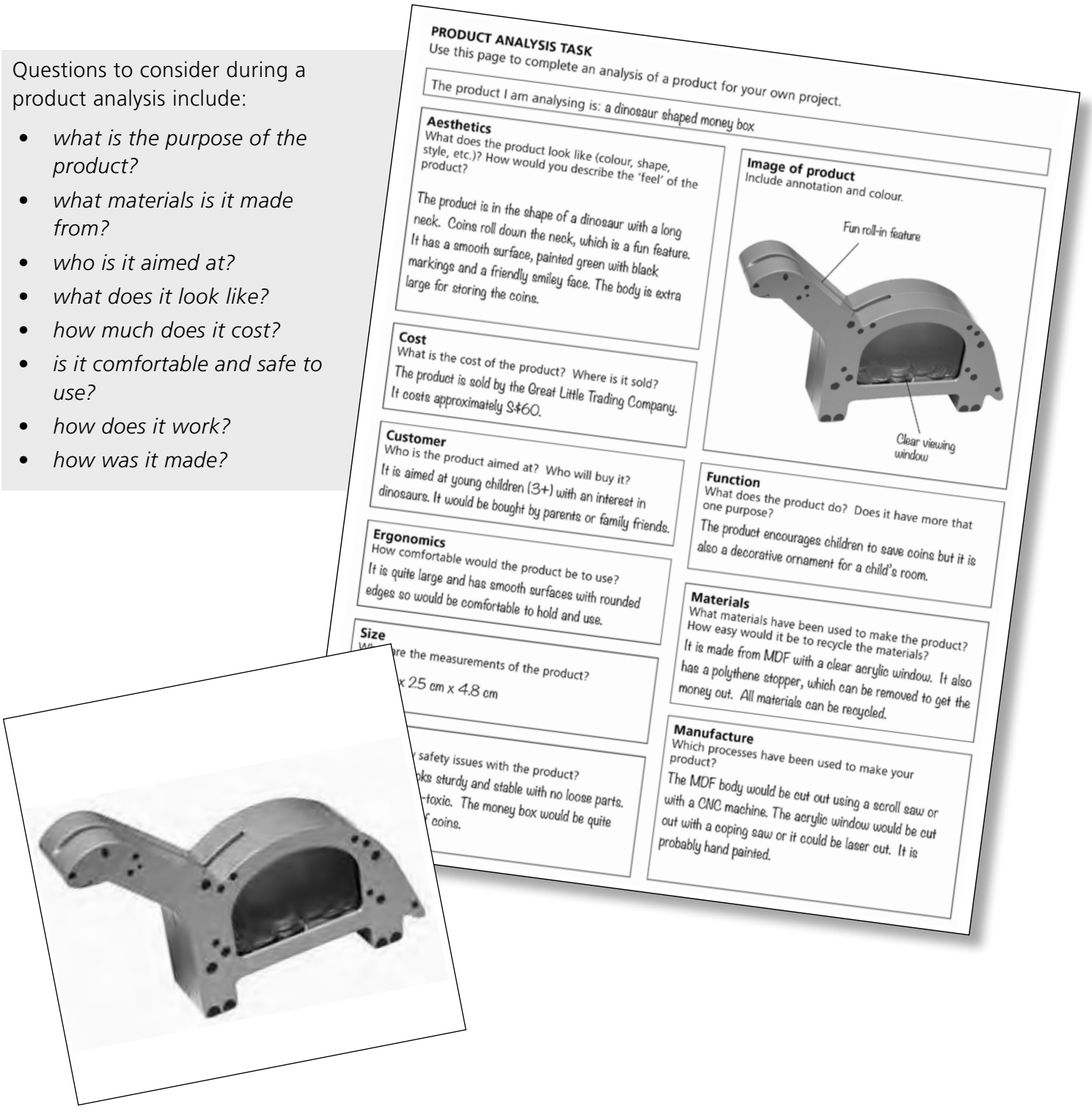
The Work of Others

Having identified the design problem you are going to solve, it is important to look at existing solutions to the problem. How have other people solved the problem? How can you use the work of other people to help you make decisions about your work? You will need to carry out a **product analysis** to help you think about things that work well or not so well in existing products. This may inspire thoughts for your own design ideas.

A product analysis of a money box is shown below.

Questions to consider during a product analysis include:

- *what is the purpose of the product?*
- *what materials is it made from?*
- *who is it aimed at?*
- *what does it look like?*
- *how much does it cost?*
- *is it comfortable and safe to use?*
- *how does it work?*
- *how was it made?*



PRODUCT ANALYSIS TASK

Use this page to complete an analysis of a product for your own project.

The product I am analysing is: a dinosaur shaped money box

Aesthetics

What does the product look like (colour, shape, style, etc.)? How would you describe the 'feel' of the product?

The product is in the shape of a dinosaur with a long neck. Coins roll down the neck, which is a fun feature. It has a smooth surface, painted green with black markings and a friendly smiley face. The body is extra large for storing the coins.

Image of product

Include annotation and colour.

Fun roll-in feature

Clear viewing window

Cost

What is the cost of the product? Where is it sold?

The product is sold by the Great Little Trading Company. It costs approximately $40.

Customer

Who is the product aimed at? Who will buy it?

It is aimed at young children (3+) with an interest in dinosaurs. It would be bought by parents or family friends.

Function

What does the product do? Does it have more that one purpose?

The product encourages children to save coins but it is also a decorative ornament for a child's room.

Ergonomics

How comfortable would the product be to use?

It is quite large and has smooth surfaces with rounded edges so would be comfortable to hold and use.

Materials

What materials have been used to make the product? How easy would it be to recycle the materials?

It is made from MDF with a clear acrylic window. It also has a polythene stopper, which can be removed to get the money out. All materials can be recycled.

Size

re the measurements of the product?

x 25 cm x 4.8 cm

safety issues with the product?

ks sturdy and stable with no loose parts. toxic. The money box would be quite coins.

Manufacture

Which processes have been used to make your product?

The MDF body would be cut out using a scroll saw or with a CNC machine. The acrylic window would be cut out with a coping saw or it could be laser cut. It is probably hand painted.

PRODUCT ANALYSIS TASK

Use this page to complete an analysis of a product for your own project.

The product I am analysing is:

Aesthetics
What does the product look like (colour, shape, style, etc.)? How would you describe the 'feel' of the product?

Cost
What is the cost of the product? Where is it sold?

Customer
Who is the product aimed at? Who will buy it?

Ergonomics
How comfortable would the product be to use?

Size
What are the measurements of the product?

Safety
Are there any safety issues with the product?

Image of product
Include annotation and colour.

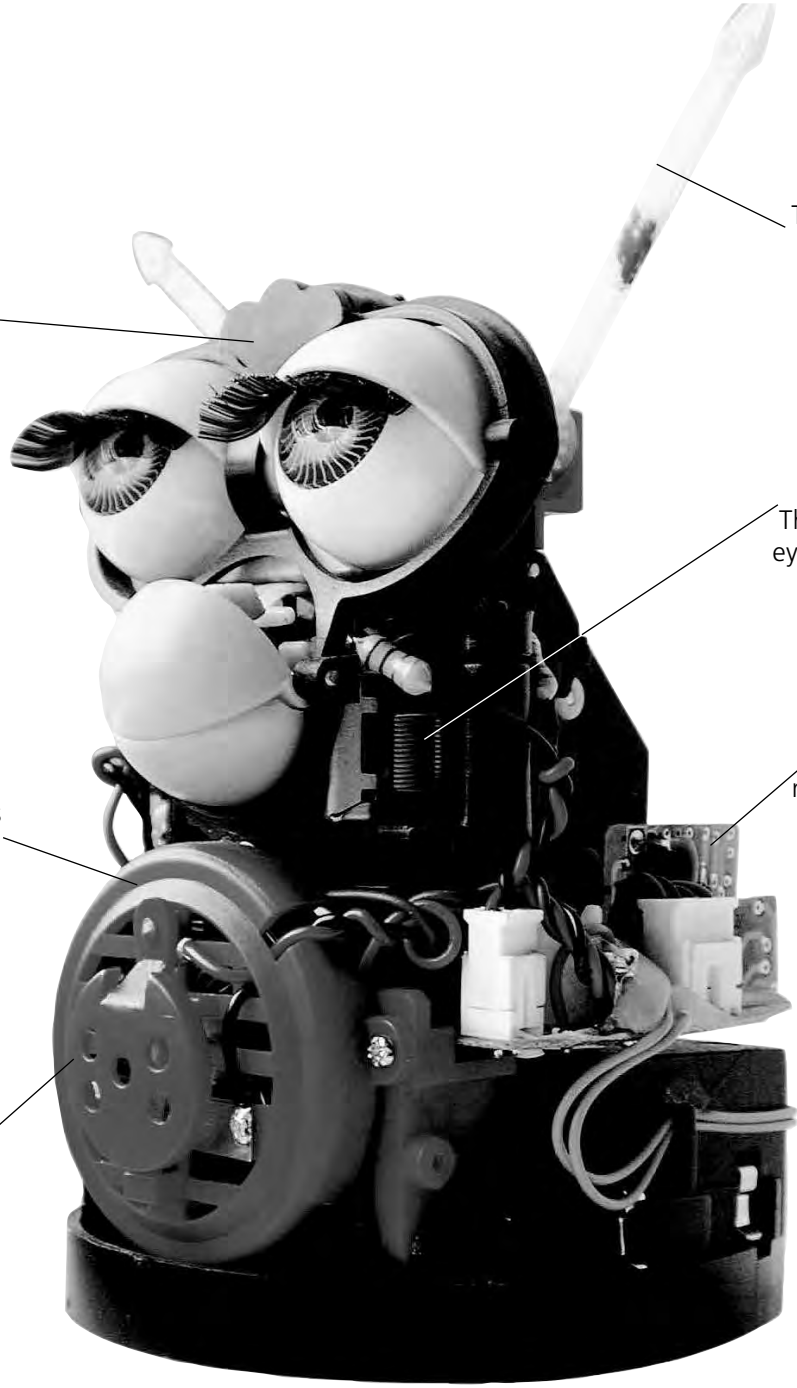
Function
What does the product do? Does it have more than one purpose?

Materials
What materials have been used to make the product? How easy would it be to recycle the materials?

Manufacture
Which processes have been used to make your product?

PRODUCT DISASSEMBLY

As part of a product analysis it can sometimes be helpful to take a product apart to see how it works. This is called a **product disassembly** and it is particularly useful for looking at electronic or mechanical parts, or to see hidden parts of a structure. A product disassembly of a robotic pet is shown below.



Important note:

A product disassembly should only be carried out with adult permission and under adult supervision.

Other Relevant Research

Some of the research you will need to do will depend on the design need you have identified. If you are going to be designing a hand-held product, you will need to research hand sizes for your target market. You could measure hand sizes yourself (primary research) or you could use tables of data that already exist (secondary research). Measurements of body shapes and sizes are called **anthropometric measurements.**

Technology Research

If you are designing a motorised product, you may need to carry out some research into mechanisms such as gears and pulleys. For example, the spindle of a small motor will spin very fast when connected to a battery - more than 100 revolutions every second.

Motor spindle spins at over 100 times per second.

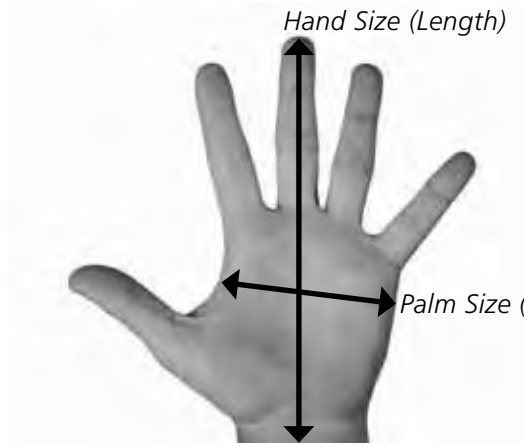
If the product has a part that must turn once every second then the gears will need to reduce the speed by a ratio of 100:1. How would this be achieved?

A gearbox can be used to convert the high speed of the motor to a slower speed.

How could a pulley mechanism be used to reduce the speed? Have a look at chapter 12.

ANTHROPOMETRIC RESEARCH TASK

Measure the hand sizes (length and width) for 10 students in your class. What is the maximum, minimum and average hand length and hand width?



Age of students: _____ *years old*

	Hand Length (mm)	Hand Width (mm)
Student 1		
Student 2		
Student 3		
Student 4		
Student 5		
Student 6		
Student 7		
Student 8		
Student 9		
Student 10		
Average		
Maximum		
Minimum		

What other hand measurements would be useful if you were designing a hand-held product?

OTHER RELEVANT RESEARCH

Use this page to present other relevant research for your project. This may include research into technology, body sizes, materials, workshop processes, safety issues or relevant news articles.

Summary of Research Presented