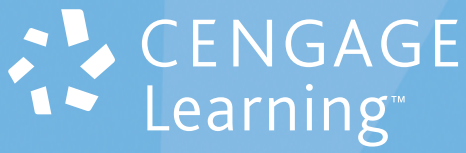
NELSON PRODUCT DESIGN & TECHNOLOGY

VCE UNITS 1–4

4th Edition

JACINTA O'LEARY
JILL LIVETT



COPYRIGHT NOTICE

Copyright in this work is owned by Cengage Learning Australia ("the work"). A condition of purchase of this electronic version of the work is that you agree to respect the copyright in the work, abide by the Copyright Act 1968 and specifically agree not to transfer, sell, assign, misuse, copy or transmit an electronic or other version of the work to any third party.

Please note: This product is accompanied by a licence (single user, network or adoption) governing the terms and conditions of its use.

This is a legal agreement between the you, (the "Customer") and Cengage Learning Australia Pty Limited (ABN 14 058 280 149) (the "Licensor") which provides the terms and conditions of this non-exclusive licence and the limited warranty for the Product. Use of the Product indicates an acknowledgement that the Customer has read and agreed to be bound by the terms and conditions of this Agreement. If you do not agree to these terms and conditions, return the Product to the place of purchase within 15 days of the date of purchase (with proof of purchase) for a full refund

1. **Licence Grant**
   You do not receive title to the Product. Copyright in the Product (which includes all images, photographs, video, animations, audio, music and text incorporated in the Product, including all of the accompanying printed material) is owned by the Licensor and/or its suppliers and is protected by Australian copyright laws. The Licensor grants you a non-exclusive licence to use the Product subject to the restrictions and terms set out in this Agreement.

2. **A Licence allows you to:**
   Use the Product on your computer. The Customer represents that they shall in no way place the Product in the public domain or in any way compromise our copyright in the Material. You agree to take reasonable steps to protect our copyright.

3. **You may not:**
   Alter, modify, translate, reverse engineer, decompile, or adapt the software or create derivative works based on the Product. Make further copies by any means technological, electronic, digital whatsoever without the written permission of the Licensor. Rent or transfer all or any part of your rights under this Agreement. Remove or alter any copyright or other proprietary notice or label attached to the software.

4. **Termination**
   Any failure to comply with the terms and conditions of this agreement will result in the automatic termination of this licence. Upon termination of this licence for any reason, the Customer must destroy or return to the Licensor all copies of the software and accompanying documentation.

5. **Warranties**
   To the extent permitted by law, the Licensor's liability for any breach of the warranty or any term implied by law into this licence is limited to the lowest cost of replacing the goods, acquiring equivalent goods or having the goods repaired.

NELSON PRODUCT DESIGN & TECHNOLOGY

VCE UNITS 1–4

4th Edition

JACINTA O'LEARY
JILL LIVETT

NELSON
A Cengage Company

Nelson Product Design and Technology VCE Units 1–4
4th Edition
Jacinta O'Leary and Jill Livett

Publishing editor: Deborah Barnes
Project editors: Aynslie Harper and Robyn Beaver
Copy editor: Nick Tapp
Text designer: Jennai Lee Fai
Cover design: Jennai Lee Fai
Cover images: Shutterstock.com/Max Krasnov; Shutterstock.com/DmitriyRazinkov; Shutterstock.com/Rattanamanee Patpong; Shutterstock. com/binbeter
Permissions researcher: Karen Forsythe
Production controller: Emma Roberts
Typeset by: Q2A Media

Any URLs contained in this publication were checked for currency during the production process. Note, however, that the publisher cannot vouch for the ongoing currency of URLs.

Acknowledgements
The publisher would like to credit and acknowledge the following sources for photographs in the table of contents: page iii: Shutterstock.com/Rawpixel.com; page iv: pixelfit/iStock.com (top), Shutterstock.com/Rawpixel.com (bottom); page v: Shutterstock.com/Ogovorka

© 2017 Jacinta O'Leary and Jill Livett

Copyright Notice
This Work is copyright. No part of this Work may be reproduced, stored in a retrieval system, or transmitted in any form or by any means without prior written permission of the Publisher. Except as permitted under the *Copyright Act 1968,* for example any fair dealing for the purposes of private study, research, criticism or review, subject to certain limitations. These limitations include: Restricting the copying to a maximum of one chapter or 10% of this book, whichever is greater; providing an appropriate notice and warning with the copies of the Work disseminated; taking all reasonable steps to limit access to these copies to people authorised to receive these copies; ensuring you hold the appropriate Licences issued by the Copyright Agency Limited ("CAL"), supply a remuneration notice to CAL and pay any required fees. For details of CAL licences and remuneration notices please contact CAL at Level 15, 233 Castlereagh Street, Sydney NSW 2000, Tel: (02) 9394 7600, Fax: (02) 9394 7601
Email: info@copyright.com.au
Website: www.copyright.com.au

For product information and technology assistance,
in Australia call **1300 790 853**;
in New Zealand call **0800 449 725**

For permission to use material from this text or product, please email **aust.permissions@cengage.com**

National Library of Australia Cataloguing-in-Publication Data
O'Leary, Jacinta, author.
Nelson Product Design and Technology VCE Units 1-4 / Jacinta O'Leary and Jill Livett.

4th
9780170400336
Includes index
For secondary school age.

Design and Technology--Textbooks.
Product design--Study and teaching (Secondary)
Technology--Study and teaching (Secondary)
Victorian Certificate of Education examination.

Other Creators/Contributors:
Livett, Jill, author.

Cengage Learning Australia
Level 7, 80 Dorcas Street
South Melbourne, Victoria Australia 3205

Cengage Learning New Zealand
Unit 4B Rosedale Office Park
331 Rosedale Road, Albany, North Shore 0632, NZ

For learning solutions, visit **cengage.com.au**

Printed in China by China Translation & Printing Services.
1 2 3 4 5 6 7 21 20 19 18 17

CONTENTS

About this book vi
About the authors viii

SECTION 1: CROSS-STUDY SPECIFICATIONS

Chapter 1: Design and designers 2
What is design? 2
Who designs? 3
What designers do 4
How designers work 5
Chapter 2: The product design process 8
Stages in the design process 8
1 Investigating and defining 9
2 Design and development 28
3 Planning and production 36
4 Evaluation 48
Chapter 3: Design and development 52
Design thinking 52
Drawing and design 59
Wood, metal and plastics 59
Fabric, fibres and yarns 68
Design aesthetics: the design elements and principles 74
Using design elements and principles: wood, metal and plastics 81
Using design elements and principles: fashion 84
Chapter 4: Product design factors 90
Product design factors 90
Purpose, function and context 92
User-centred design 96
Innovation and creativity 102
Visual, tactile and aesthetic factors 103
Sustainability 104
Economics 107
Legal responsibilities 108
Materials 114
Technologies 116
Chapter 5: Sustainable design 119
Sustainability 119
Environmental impacts 121
Case studies for sustainable design 131

9780170400336

SECTION 2: MATERIALS AND PROCESSES

Chapter 6: Classifying and testing materials 140
Classifying materials 140
Resistant materials 142
Non-resistant materials 147
Materials testing: all materials 151
Chapter 7: Resistant materials and processes 158
Wood 158
Metal 181
Plastics 194
Case studies for resistant materials 203
Chapter 8: Non-resistant materials and processes 214
Properties of textiles 214
Fabric production and properties 218
Issues related to textiles 222
Processes for fabrics, fibres and yarns 224
Case studies for non-resistant materials 238

SECTION 3: UNITS 1 AND 2

Chapter 9: Unit 1: Sustainable product redevelopment 246
Content of Unit 1 246
The product design process 247
The product design factors 247
Analysing a product to redevelop 250
Unsustainable products 252
Redeveloping a product 254
Design and development 257
Planning and production 259
Knowledge of materials 261
Evaluation 263
Case study for Unit 1 264

9780170400336

Chapter 10: Unit 2: Collaborative design 268
Collaboration 268
The product design process 269
Researching a style or movement 270
Why teamwork? 272
Approaches to teamwork 273
Working as a team 275
Presenting your work 284
Case studies for Unit 2 285
Chapter 11: Design inspiration 291
Inspired by styles 291
Fashion styles 292
Australian fashion design 304
Australian Indigenous textiles 314
Furniture design 316
Australian furniture design 325

SECTION 4: UNITS 3 AND 4

Chapter 12: Unit 3: Applying the product design process 333
Essentials for Unit 3 333
Area of Study 1: Designing for end-user/s 335
Case studies for Unit 3, Area of Study 1 342
Area of Study 2: Product development in industry 348
Case studies for Unit 3, Area of Study 2 364
Chapter 13: Unit 4: Product development and evaluation 377
How we choose products 377
Defining product attributes 378
Factors as attributes 379
Prioritising product attributes 382
How products are evaluated 384
Comparing products 386
Chapter 14: The SAT: Folio, product and evaluation 389
An overview of the SAT 390
Unit 3, Area of Study 3: Designing for others 390
Unit 4, Area of Study 2: Product manufacture 405
Unit 4, Area of Study 3: Product evaluation 409
Chapter 15: The Product Design and Technology exam 412

Index 426

9780170400336

ABOUT THIS BOOK

Nelson Product Design and Technology VCE Units 1–4, 4th edition, has been updated to match the new *VCE Product Design and Technology Study Design 2018–2022*. This improved design endeavours to give you a better, clearer and more useable book.

Sections 1 and 2 have relevant information for all four units (both Year 11 and Year 12).

Section 1 covers the key cross-study specifications that underpin the whole study of Product Design and Technology, with particular focus on the **product design process** and the **product design factors**.

Section 2 contains cross-unit information about **materials** and **processes**. It provides general information about classifying and testing materials, and then specific information about materials and processes used in different categories – wood, metal and plastics, and textiles.

Section 3 has more detail on Units 1 and 2, with a chapter on styles. Section 4 has more detail on Units 3 and 4, with a separate chapter on the SAT. Throughout Units 1–4, Sections 1 and 2 need to be constantly referenced. You will find **cross-references** in the unit chapters that direct students to the page number and/or chapter where they can revise the specific information.

All key knowledge and key skills are fully covered in the cross-study specifications chapters (Sections 1 and 2), and the specific unit information chapters (Sections 3 and 4).

In each chapter

The text is clear and easy to read, with plenty of illustrations, tables and graphs to explain concepts. Real world case studies, articles and interviews throughout the text relate theory to real life designers working in Australia and overseas. Actual student folio examples are scattered throughout the text to aid student comprehension. Chapters open with an outline of the chapter contents ('Chapter focus'), so you can see at a glance what the chapter will cover. Margin definitions also help students with new terms on the spot.

Unit-relevant highlighting

Section 1 and Section 2 both contain information that is covered across all units. To help students and teachers determine quickly which text is relevant, unit-specific text is indicated by a coloured line in the margin that aligns with relevant text. Text for Units 1 and 2 has **orange** lines, as in the example below:

- Have an evaluation criterion for each of the **three points of difference** between your design and the existing product (or prototype) you are redesigning.
- Ensure that at least one of these relates to the improved sustainability of the redesigned product, i.e. how well you have lessened the negative impacts of the product.

Text for Units 3 and 4 that features in Sections 1 and 2 has **blue** lines, as in the example below:

- Other passions and lifestyle interests.

These details help the designer to make appropriate design choices about product function, cost, appearance and style, ergonomics, materials and durability. A need

9780170400336

Margin features

The margin features within the chapters include glossary definitions, weblink and safety warning icons, and FYI notes.

- **Glossary definitions** for the glossary words (bolded in **brown** throughout the text) are in the margin and at the back of the book. If you are using the nelsonnnetbook, there is a button at the top of each page to see the glossary terms as you read.
- The **weblink** icon indicates a helpful website. Weblinks can be accessed directly through http://nelsonpdtvce.nelsonnet.com.au.
- The **safety warning** icon indicates when special care needs to be taken or further training is required when using equipment, materials or processes, or if there is a specific safety concern.
- **FYI notes** provide snippets of information that may be of interest to students. These are always in the margin.

user-centred design design that focuses on the user or certain shapes

Annotations are an important tool to articulate and communicate design thinking.

On your website

For each chapter, there are individual and class activities and useful websites.

The activities will provide you with different ways to reinforce what you have learnt through reading the chapter, and supply significant tasks that will help you to satisfy unit outcomes.

There are also **revision cards** that will help you with exams and your SAT. These can be downloaded to your smartphone.

These revision cards are in sets: Chapter 2 has cards on the product design process and on planning; Chapter 3 has revision cards on drawing types, and Chapter 4 on product design factors; Chapter 12 has revision cards on product development in industry, and Chapter 13 on product analysis and comparison. Finally, there are revision cards on key terms at the end of Chapter 15.

There are also **templates** that go with the workbook tasks, so you have the option of filling them in online.

In addition, the templates from your PD&T workbook are also online. These include:

- End user profile
- Evaluation criteria for design options
- Evaluation criteria for the finished product
- Research plan
- Design options scoring grid
- Materials list and costing:
  - wood, metal, plastic
  - fabric, fibre
- Production steps
- Timeline for production
- Risk assessment sheets:
  - production
  - work environment
  - product
- Journal
- End user feedback log
- Modification sheet
- Product evaluation
- Mind map template

We hope you enjoy the new digital material, and of course your textbook and workbook!

ABOUT THE AUTHORS

Jacinta O'Leary has taught Woodwork, Plastics, Junior Electronics and Visual Communication Design in various schools in Victoria. She currently teaches at Distance Education Centre Victoria, where she created courses for Design and Technology in the junior level, VCE Visual Communication Design, VCE Food and Technology and VCE Product Design and Technology.

In 2010 Jacinta was the chief writer for the VCAA review of *VCE Product Design & Technology 2012–2017*. In 2015 and 2016 she contributed to the VCAA Assessment Criteria for the major task for this subject and she has been an exam assessor for many years.

She has been a board member of the Design and Technology Teachers Association Victoria (DATTA Vic) since 2007, writing and editing DATTA Vic teacher support material for VCE Product Design and Technology and giving numerous presentations, both to teachers and students, on the subject.

Jill Livett has been teaching Technology Studies for over 20 years in state and independent schools. During that time, she has taught classes in VCE Wood and Fabrics, and Years 7–10 Design and Technology in the areas of Wood, Metal, Plastics and Fabrics, and Systems Technology. She currently teaches Years 6–9 Design and Technology at Overnewton Anglican Community College.

Jill has supported the teaching of the Design and Technology learning area by organising and presenting workshops, developing curriculum material and organising conferences for DATTA Vic and the VCAA. She has taught Technology Education subjects at a number of universities, and is currently the Vice President of DATTA Vic.

From the authors

The authors would like to express their gratitude to their friends and families, particularly our spouses, Mark and Peter, for their constant support, and for putting up with a 'missing person' during the writing process. Thanks also to all the designers out there who gave their time generously, and the many students from Distance Education Centre Victoria and various schools who kindly gave their work, for this book.

9780170400336

SECTION 1

CROSS-STUDY SPECIFICATIONS

Chapter 1: Design and designers 2

Chapter 2: The product design process 8

Chapter 3: Design and development 52

Chapter 4: Product design factors 90

Chapter 5: Sustainable design 119

Shutterstock.com/Rawpixel.com

9780170400336

Shutterstock.com/Rawpixel.com

CHAPTER 1 Design and designers

CHAPTER FOCUS

In this chapter you will learn about:

- What is design? p. 2
- Who designs? p. 3
- What designers do p. 4
- How designers work p. 5

WHAT IS DESIGN?

What is design? Is it drawing something that looks good? Is it making something? Is it thinking up a good idea? Is it fiddling around until something works?

Design is all of these things, and more. It has been happening for thousands of years, making use of changes in technology over the millennia.

Design is a process that sees something from the initial recognition of a problem through to creating something new to solve that problem. Design also looks for opportunities, and persists with a germ of an idea until something real and useful is created. It is a process that investigates the problem or opportunity and its context, researches and considers a range of possibilities, and then creates and evaluates a solution. The thinking that a designer does through the process is critical. A designer uses all their skills – both practical and theoretical – as well as their knowledge, understanding, sensibilities, reflections, and their creative and critical thinking through every stage of the process.

In the broader context, a design 'solution' might be a product or object, but it also might be a system or process, or a service. However, within the context of this book and your studies, design is about the process that creates a useful, three-dimensional (3D) product that is **functional** and **aesthetically** pleasing (i.e. it works well and looks good). The end product can be made from timber, metal, plastic, ceramic, glass, fabric or fibres, or a combination of some or even all of these materials.

function how a product works, fulfils a purpose, 'does its job'

aesthetic related to the visual and sensual aspects of a product; associated with beauty and style

9780170400336

What is 'good' design?

'Good' design is evident in a product when a designer uses all their thinking skills – combining their creative and practical capacity. Good design doesn't need all of the following qualities, but usually has at least two or three. It is a product that may:

- function really well to solve a practical problem or meet a need
- use the design elements (shape, colour, line, texture, etc.) and principles (contrast, repetition, proportion, symmetry, pattern, etc.) with understanding and a certain level of flair. *To find out more about the design elements and principles, go to page 74.*
- be designed to suit its context, environment or situation, and the people using it.

Good design should also:

- deliver a bit more – i.e. do what it needs to do, either to a higher level, or with something extra
- be as durable and as sustainable as possible
- use materials and construction processes well, perhaps with a bit of a twist
- have a high level of quality – materials and processes that are the best available, finishes that are well done, etc.
- be uncluttered and free of irrelevant details
- surprise or challenge.

Good design doesn't have to be expensive (although it sometimes is, because thinking about design can take time, and good materials and processes can be costly). Something very simple and inexpensive may have been refined and improved over many years through use and adaptation, and be a fine example of good design. The opposite is also true – that expensive design isn't always 'good'.

In addition, good design is subjective. People have differing priorities when they judge the design of a product. An object that one person thinks is great for aesthetic reasons might be thought of as useless by someone else who isn't impressed by the way it functions.

WHO DESIGNS?

Does an engineer design? Is a scientist also a designer? Does an artist design as well as create? What about someone who plans stage lighting? In a broad sense, you could say 'yes' to all of these questions: all of these people go through a process that devises a solution for a problem. The nature of their problems and the contexts are different. The end 'products' also vary – from a bridge or machine, an experimental procedure and apparatus, a painting or sculpture, through to a sequence of different lighting 'scenes'. A designer considers, works through or satisfies all phases of the design process, regardless of the material or media they use. Designers also draw on the specialist knowledge of others to assist and inform them during the process.

People use the design process within a wide range of circumstances. In this VCE subject, we focus on designers who create 3D products that solve a problem and that have both a functional and visual aspect to their design. Some designers work in a large or small commercial business; they are one link in a chain of people who develop and produce a product or range of products. Other designers work as consultants, or as part of a consulting firm – a manufacturer, organisation or **client** employs them to create a design specifically for their business, or their services are commissioned. There are also other designers who work independently on commissions, or on self-driven projects related to a user need they have identified.

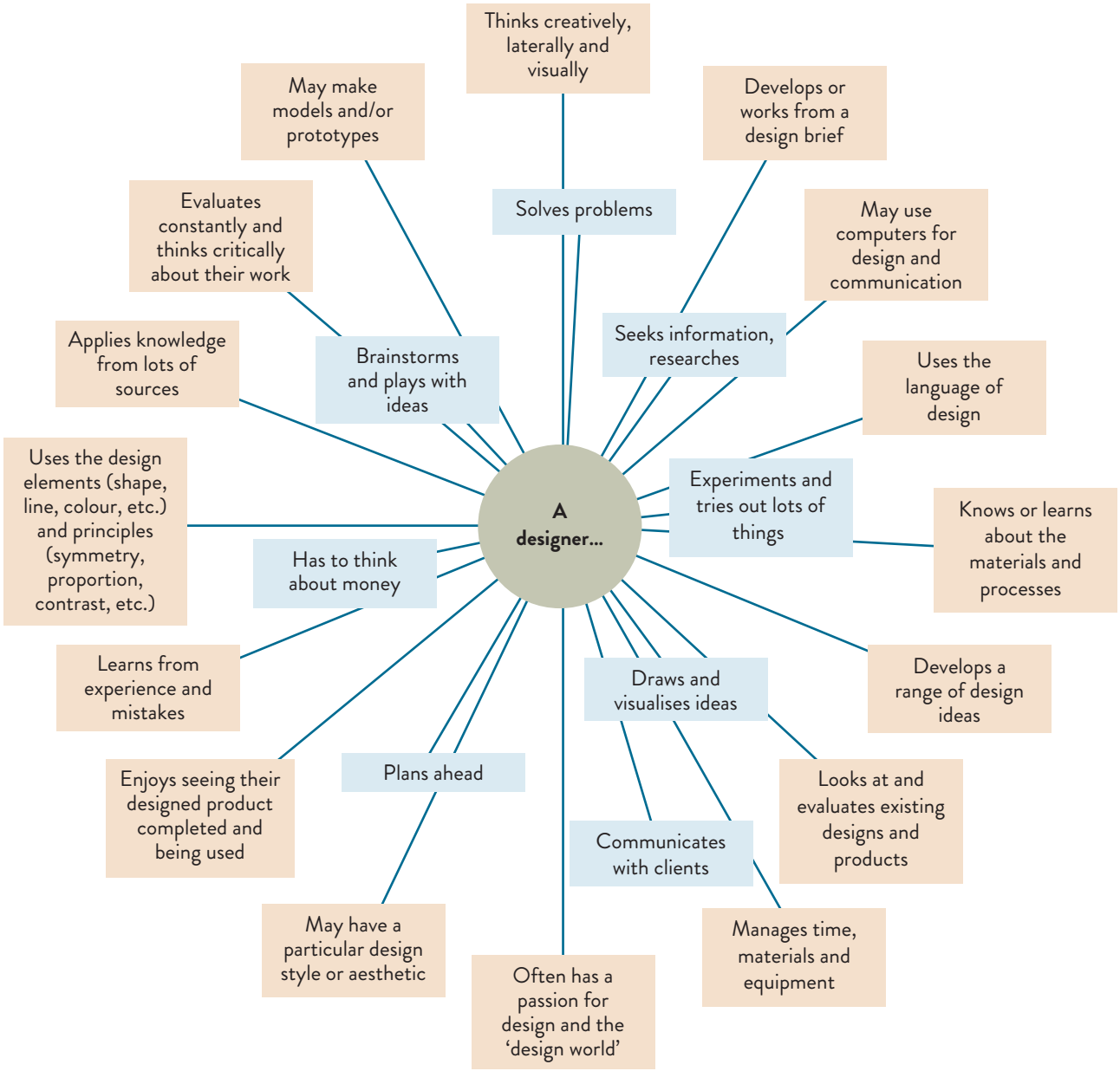
client
a person who has employed or commissioned a designer to create something

9780170400336

Many designers combine two or more ways of working. Sometimes they use more commercial or lucrative product design or consultation work to provide financial support for time spent on more creative or experimental work. Some designers work part-time in a salaried position to support their lower paid design work, particularly in the early years of establishing their design profile or business.

Chapters 10–14 have lots of information about how designers work, plus case studies about designers working in different fields.

WHAT DESIGNERS DO



9780170400336

HOW DESIGNERS WORK

Designers have widely varied approaches to designing, depending on the situation and their personal style. Most designers have different starting points in terms of how they identify the need for a product, and use diverse sources for their design inspiration. They also have distinctive ways to develop and visualise their ideas using different drawing techniques and materials. The following examples help illustrate the many different ways in which real designers work and the methods they use to design.

Martin Grant, a clothes designer born in Melbourne and now living in Paris, has his own established label. *See the profile of Martin on page 307.*

> His working method is focused on the development of a design through the direct manipulation of fabric on a dressmaker's mannequin. Designs rarely begin as a detailed two-dimensional sketch, but emerge from an image held in Grant's imagination.
>
> From 'Martin Grant, Paris' catalogue by Katie Somerville, 2005 © National Gallery of Victoria, Melbourne

Melbourne product designer **Marc Pascal**, on the other hand, captures his initial ideas by sketching on paper first, and then works with the computer program Rhino 3D. He may add to his sketches and, if possible, will draw at the moment when the inspiration comes. When working with clients or commissions, he also starts with sketches on paper, but these are soon drawn up accurately by electronic means. *See the case study on Marc on page 364.*

Many clothes designers, such as those at **Metalicus**, use **tear sheets** for inspiration. These are laid out on a table, then the designers select and reject different ideas and, from here, decide upon a theme. Most design decisions come after looking at the fabric. Then the designers look at other bits and pieces – such as zippers, trims and snap closures from their suppliers – and make sketches. From this presentation, or 'mood board', they design a range. Once the samples of the range are finalised, the designers use Illustrator to make up specification sheets to give to the manufacturers. *Research Metalicus online. To find out more about mood boards, go to page 56.*

tear sheets pages from magazines that include visual images of clothing, textures, natural objects, specific colours or certain shapes

Shoe designers **Johanna Preston** and **Petr Zly** take a similar approach, using a pin board to attach pictures torn from magazines, small thumbnail sketches of ideas, and notes on design features and styles. At the beginning of the design phase of each season, they use these snippets of ideas to provide stimulus for designing their range of shoes. Because they are both very experienced and have worked together for many years, they use a form of design 'shorthand' and can communicate their ideas to each other in straightforward sketches. Their collaborative design process has developed to accommodate their individual approaches to designing. *Research Preston Zly shoes online.*

Getty Images/Caroline McCredie

Clothes designer **Akira Isogawa** was born in Japan, lives in Sydney, and has his own established label. He first worked with old kimonos, cutting and shaping them into new outfits, with no drawing or computers involved. A lot of his early work was about changing historical and cultural fabrics into contemporary pieces. When preparing for a collection in Paris in 2004, he used miniature paper dolls onto which he pasted

9780170400336

fabric, leaves, brooches or other objects, and found his inspiration from the results. He has also used pieces of origami and printed words as a basis for designs. *See the profile on Akira on page 308.*

Thanks to his training, knowledge and experience, jeweller **Marcos Davidson** is usually able to start with a picture of the finished object in his head. If necessary, he will draw up some sketches and nut out the sequence of production, along with the techniques needed. When dealing with clients he uses the 'bespoke' method, which entails the client 'speaking' about what they want or need and the designer making sketches. Due to the preciousness of the metals involved, a sample is always made up first. *See the case study on Marcos on page 209.*

Metalworker **Jacki Staude** often takes inspiration from the natural environment or intended location of her work. She talks with clients, shows them previous work, makes suggestions and then makes several quick sketches on paper. With client input, these ideas are refined. Her working drawings are all done by hand on a drawing board. They usually consist of two-dimensional (2D) scale drawings, plans, elevations and a site sketch. She works directly from these drawings. *See the case study on Jacki on page 206.*

Getty Images/Cindy Ord

Alamy/Ho/Romeo Balancourt

Grant Featherston, an Australian furniture designer of the 1950s and 1960s who pioneered the use of shaped and bent plywood for seating, bent and looped strips of paper to explore shapes for his chairs. These 3D experiments were the starting point for his design sketches (*read his profile on page 326*).

Karim Rashid is a world-renowned designer of products, and believes that 'products should reflect their time'. He uses current technology to assist him in creating a contemporary product, including drawing programs, data banks, CAD and/or CAM (computer-aided design and computer-aided manufacturing), the Internet and the latest technological processes.

The well-known Australian designer **Marc Newson** always carries a notebook, in which he sketches ideas and scribbles notes about projects. Originally, these ideas were formed into products using a fairly traditional process, from hand-made models to **prototypes** for production. He now uses fairly advanced computer software that transforms a concept into a production-ready project through rapid prototyping technology. *See the profile on Marc on page 327.*

Nicola Cerini, an accessories and clothing designer from Melbourne, keeps sketchbooks with drawings from nature and photos taken on walks. These are the source of her ideas. When designing fabrics for bags or clothing, she will scale these images to suit the product. From here, there is a lot of exploration with

prototype
3D version of a product's design used to test a concept and/or performance before the product goes into production of multiples

the images, colours and different fabrics. Prototypes are made and patterns are cut from the best ones. She feels that her sound drawing skills and visual design training have helped her immensely in her business. *You can link direct to her website via http://nelsonpdtvce.nelsonnet.com.au.*

Jørn Utzon, the Danish architect who designed the Sydney Opera House, was taught by his father, a naval architect, how to use nature as stimulus. He was also inspired by some of the greatest architectural buildings in the world, especially ancient ones that have withstood the test of time.

Utzon combined his precise skills in technical drawing with free-flowing forms to create the unique shape of the Opera House. The basic roof shape was based on the shape of a ship's hull. He also used small models to work out solutions, e.g. the peel of an orange cut into small pieces helped him to work out the structure of the roof shells.

Fairfax Syndication/Rob Banks

Shutterstock.com/Debra James

The Sydney Opera House, designed by Jørn Utzon

The Opera House was a massive project for Utzon. His participation lasted for nine years and involved a lot of travel, research, experimentation and trials. Some of these activities were driven by his desire to achieve perfect results. Many scale models and prototypes were made to test different aspects, such as engineering possibilities and the function of the Opera House interior (to provide good acoustics).

You can find interviews with designers such as Karim Rashid, Marc Pascal and others mentioned in the preceding pages by typing their name into a search engine.

Different fields, different perspectives

Designers in other fields often come with a different perspective to those of fashion designers, architects or jewellers. A good example of this is in the water sports or surf industry. Many designers of products such as wind boards, kite boards, wetsuits and other gear have a background in engineering or a similar discipline. Their passion for water sports or surfing, combined with their past experience and training, fuels a desire to create better, safer, faster or warmer products – often starting with a common complaint or a personal need that they feel sure is widespread among fellow sportspeople.

9780170400336

Shutterstock.com/Photographee.eu

CHAPTER 2 The product design process

CHAPTER FOCUS

In this chapter you will learn about:

- Stages in the design process p. 8
- Investigating and defining the need – the design brief, evaluation criteria and research p. 9
- Design and development – formulating design ideas (visualisations), design options and working drawings for the preferred option p. 28
- Planning and production – plans, scale models, construction of a prototype and/or product, and documentation p. 36
- Evaluation – of the product p. 48

STAGES IN THE DESIGN PROCESS

While there is a universally accepted process for approaching successful design, there are many different interpretations and versions of this process. These are as varied as different versions of one product to meet different needs. Each approach to the design process may be customised by its designer to deal with their particular situation.

In addition, many companies have their own unique design process, which has been moulded to suit their particular products.

In reality, designing is not a simple lockstep – or standardised – procedure, where one stage must be entirely finalised before moving on to the next. Often, investigation or further development of an idea will lead to a completely new avenue of research that requires a change in direction. For example, if a material is discovered to be unavailable after a design has been finalised, this may create the need for more research, or testing of alternative materials.

The product design process in VCE provides a framework within which you, as students, can document your entire design project from the initial idea to the finished product. It outlines four broad stages, plus steps within each stage.

While you should find the VCE product design process helpful, particularly if you are new to this study, it is not a definite order of steps set in concrete. It is a suggested structure; within which you can jump around if necessary. Flexibility in applying the design process is also essential to managing your time and other resources effectively.

9780170400336

Below is an outline of the stages and steps of the product design process in VCE. Use this as a framework for your design experience, but remember to maintain the necessary flexibility to modify it as required.

Stages and steps in the product design process

1 Investigating and defining the need

- Investigating or recognising needs, problems, opportunities or situations that could be improved by design; selecting an end-user
- Clarifying the situation, the context, the user and the **constraints** and **considerations** in a **design brief** with the relevant **product design factors**
- Creating criteria for selecting the preferred option and evaluating the end product and its quality
- Researching the situation, for inspiration and the relevant product design factors

To find out more about product design factors, go to Chapter 4.

2 Design and development (conceptualisation of ideas)

- Visualising – including the use of graphic organisers, concept sketches and drawings; exploring the design elements and principles; experimenting with functional aspects, materials and construction techniques; using mock-ups and 3D models to explore ideas and solutions
- Preparing design options in the presentation drawing style as realistic solutions to fulfil the brief; applying evaluation criteria to select and justify a preferred option
- Creating working drawings with **product specifications** to construct the preferred option

3 Planning and production

- Devising a scheduled production plan that shows the production steps; tools, machinery and equipment needed; timeline; materials list and costs; risk assessment and quality measures
- Building a scale model or a **toile**, if appropriate, to check the design and specifications
- Constructing the product (or a full-sized prototype)
- Documenting progress with images and text

4 Evaluation

- Using product evaluation criteria and checking methods to assess the quality of the solution
- Recommending improvements to the product and its quality

constraints
the limits of a situation; the 'must haves'

considerations
aspects that need to be considered or investigated further

design brief
a written statement outlining the design problem and its requirements (the constraints and considerations)

product design factors
aspects that influence design

product specifications
all the details required to construct the product

toile
a full-sized version of the finished garment made out of an inexpensive fabric, such as calico

1 INVESTIGATING AND DEFINING

The first stage in the product design process for VCE is called 'investigating and defining'. It covers the steps of:

- identifying the end-user, need, problem or opportunity through investigation or research
- defining the need and its requirements in a design brief
- extracting evaluation criteria from the design brief to use later to select the preferred design option and to evaluate the finished product
- carrying out relevant research.

9780170400336

Identifying the need

The first step in the product design process can be expressed in many ways, but it is really about finding the reason to create something new. This step may be expressed as identifying a need or opportunity; finding a problem to solve; looking at a product that needs improvement; establishing requirements; researching or investigating a market niche; identifying a design situation; or enlivening and evolving existing designs.

Perceiving a need through personal experience

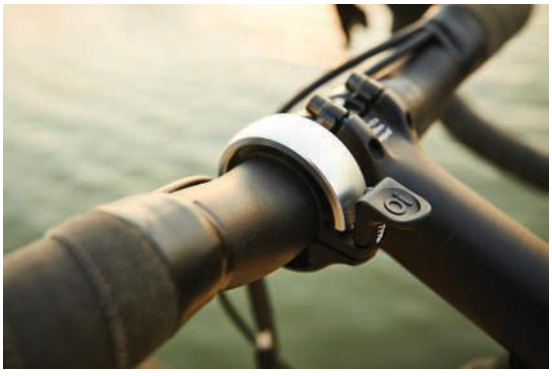
Needs are often identified as a result of some daily activity, or through interaction with others who have identified a need because of personal experience or direct observation. Specific problems may have been encountered, or a designer may wish to achieve something unique. You can see the varied approaches in many of the case studies in this book. *Read the case study on Jim Hannon-Tan on page 373.* After chopping up chillies, his fingers felt burnt for a day or so. Hence the *Piccantino* chilli storage and crusher was designed.

A need to improve something

ergonomics the science of designing equipment and products to match the human body and the way it is used – to reduce injury, fatigue and discomfort

The need may come from the desire to improve something **ergonomically**. For example, both men and women are growing taller, so architects and product designers have to consider this in order to cater for a tall person's comfort. Door handles may need to be placed higher; baby pushers may need to have higher handles, etc.

Another example is that people are living longer and sometimes this means an increase in the incidence of arthritis or reduced mobility. Designers of products therefore need to think ergonomically about how arthritis sufferers can manage particular handles, levers and other functional aspects of products.



Knog, www.knog.com.au

The *Oi* bike bell by Knog

Market-led designs or opportunities

There are also a number of successful design ideas that were almost entirely market led during their development. In these instances, someone has identified a gap within an existing market and gone on to create an appropriate product or solution. Yap Wear – Urban Dog Essentials clothing for pets, for example, was created by a pet owner who had seen pet fashion in Europe and couldn't find what she wanted in Australia.

The pursuit of leisure and sporting activities also gives rise to a variety of needs. A good example is the bicycle bell called *Oi* by Australian company Knog. They wanted to create a bell that was much more aesthetic than traditional bicycle bells.

The product design factor of user-centred design covers more areas for you to consider when identifying a need. *Read more about this factor on page 15.*

Identifying the end-user/s

design problem a situation, opportunity, product or activity that can be improved by design

As a VCE student, you are looking for a personal, local or global **design problem** to be solved for an end-user. This can be similar to being commissioned by a client to create a one-off piece (i.e. for one end-user), designing a product for typical end-users of a particular target market or designing for a broad group of end-users, as listed in the table on the following page. If designing for yourself, you would see yourself as a member of a target group, i.e. as part of a group with the same tastes, lifestyle, budget, etc. Some of you may choose a problem that is outside your own world, i.e. for a particular group of people you know little about and need to research.

9780170400336

Examples of end-users

One end-user	Typical end-users of a target group	Broader end-user groups of a situation
A family member, friend, teacher, neighbour, community member	Male teenage skaters/surfers; 20- to 30-year-old female city office workers; labourers who carry tools; people needing gym-to-office wear; board members or families requiring furniture; children in a child-care centre	Arthritic sufferers; slum dwellers in Asia; blind people, bed-ridden patients; people without access to clean water; city workers who drive to work; people who live in cities with toxic air; consumers interested in sustainability

Ways of identifying a need

To identify a need, you as the designer can:

- observe friends or family to determine any needs they may have
- look at your own peer group and any needs they may have
- talk to a typical end-user about their needs and requirements
- examine consumer demand or gaps through market research
- research and be aware of new technologies that could create new needs and opportunities
- reflect on and draw from your own experiences
- observe problematic situations that could be improved with good design
- be aware of social trends
- listen to people with a special need
- be creative in making projections about what people might need in the future.

Interview or market research

To create a profile (see below) you will interview one or more end-users or refer to market research. Use the product design factors as a basis for your interview questions. Create one or more relevant questions for each factor that applies to your design brief context. It is possible that not all the factors are relevant to your brief.

See examples of questions under 'Content for constraints and considerations' on pages 14–16. Adapt these questions to suit your design problem, intended product type and end-user.

UNIT 3

User profile

A profile of the end-user is a folio requirement in Unit 3. Use the responses to your interview questions or market research to create the profile. It does not need to be detailed with private information, but it should paint a picture of the user/s in relation to their situation.

Some suggestions for information and images to include are:

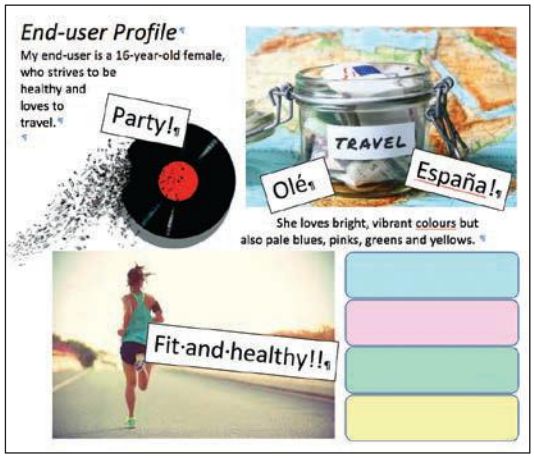
- gender or age bracket
- their taste or things they like visually (colours, lines, shapes, textures, objects, architecture, etc.)
- specific needs (if different to most people's)
- values – attitudes to spending, sustainability, quality, function or aesthetics
- passions and lifestyle interests that are relevant.

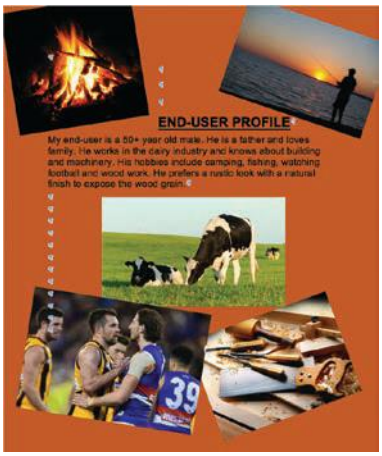
This profile can help you to make appropriate design choices by defining the end-user. For example, a need or problem for a young male adult will be different to one for an elderly female.

If your design brief is for a typical end-user in a target group, it helps to collect pictures of people that depict this group.

Although the intended user will be mentioned in your design brief, a visual profile in your folio (with images, textures and colours) is a faster way of communicating who they are and their 'tastes'. Include visuals of objects, architecture, things from nature that might interest the user, or of a typical environment they will be in.

9780170400336





End-user profiles by students (left to right) Sam Rivera, Isobel Connell and Adam Hamilton

primary need
the main reason why the product (solution) is needed

Once the **primary need** or purpose has been identified, associated needs or requirements are determined and defined in a written design brief. Examples of associated needs include correct sizing, safety requirements, materials, aesthetics, desired quality, etc. Using the product design factors as a guide will help you with this.

The design brief

A design brief is a written statement outlining the design problem and its requirements. A well-formulated design brief is important because it sets the direction for the design process. It should not be overly detailed (one A4 page is sufficient) and it should not be a description of a product, but rather an explanation of the problem, need or opportunity. It makes reference to relevant product design factors. *To find out more about product design factors, go to Chapter 4.*

The design brief has two parts:

Part 1 An outline of the context or situation
Part 2 Constraints and considerations.

Part 1 Outline of the context

The outline of the context explains the problem to be solved, or the need to be met. It states the target group or end-user and outlines the reason for their need. It includes the major purpose or intended function of the product, where it will be used, how often it will be used, and when and under what conditions it will be used. It includes background information about the particular event, activity or purpose that the product is being designed for (e.g. indoor/outdoor; formal/casual; summer/winter; workers in Cambodia; people with missing limbs; people without electricity; a proposal to make use of recycled materials) and other relevant information (e.g. the product will be used roughly or the end-users love clashing colours).

Remember that defining the end product at this point can lead to reduced creativity and can thus limit the potential for innovation. Check that your brief is an outline of a design problem, and not in any way a description of a product. For example, instead of stating that a chair is needed, describe it as a problem by saying: 'there is nowhere to sit …'

If designing for one end-user in Unit 3, encourage them to give you an open problem. Explain that asking for a set, well-defined specific product will severely limit your design input and creativity.

Here are some examples of the outline of a problem and its context:

For one end-user

My neighbour loves to garden but she has fair skin and suffers easily from sunburn. She needs her arms and neck to be protected fully from the sun while she is outside. She also needs to be able to move freely and keep cool. She has a lot of rose bushes and so needs protection from the thorns. She needs a one-off design as she is very tall and thin and can't buy a garment to suit this activity. As she will be washing it regularly she expects it to be of a robust quality to withstand this.

For end-users in a target group

Building and outdoor industry employees, who are subjected to extreme levels of UV radiation during summer work hours, need a low-cost method of shielding their eyes. They work up a sweat on the job and aren't able to use their hands to make adjustments to their headgear. A safety product manufacturer requires a new design to suit these end-users. All products manufactured by this company have strict quality standards that will need to be adhered to.

Broad end-users

Peeling pumpkins can be a very difficult job. Depending on the type of pumpkin, the skin can be very hard to separate and the awkward shapes of the pumpkin make it difficult to hold. I would like to design a 'pumpkin peeler' that is easy to use, safe and looks great. My end-user would be a typical family cook, of adult age, who needs a good, safe product. They would be prepared to pay for this product as not only will it work for them, it will be an eye-catching implement in the kitchen.

Part 2 Constraints and considerations

The detailed requirements of the situation are called constraints and considerations.

Clarification of the requirements is essential for a suitable solution to the problem. Note, however, that some professional practitioners state that 'including [too many] requirements limits the creative thinking process to preconceived solutions and discourages the consideration of new concepts' (Kaufman and Woodhead, *Stimulating Innovation in Products and Services: With Function Analysis and Mapping*).

Constraints are the aspects that are 'concrete', can't be changed, or that the product must fulfil. In the example of the eye protection brief above, an obvious constraint would be that the product must comply with Australian Standard AS/NZS 1067:2003 and provide 100 per cent UV protection. In the example of the gardener as end-user, protection is also important, but another constraint would be that the resulting garment must be the correct size. Cost might be another constraint. You as a student will have a budget or a cost limit on materials.

Considerations are other aspects of the design brief or situation that must be thought about or considered. These are the details or aspects that often require more research, or that are dependent on some other information.

They are not design possibilities, such as 'Will there be short sleeves or long sleeves?', as these sorts of issues can be worked through at the 'idea sketch' or 'design option' stages. Again, they are not a description of a final product; they are aspects that will have some impact on the use or appearance of the product and need to be considered.

9780170400336

In the example of the eye protection for building workers, two considerations are comfort and the weather. If the product isn't comfortable on hot days, the workers won't wear the product and will not gain the benefit of UV protection. The designer will also need to consider rainy weather and visibility. Considerations of comfort in the heat would require an exploration of ergonomics and possible product shapes, suitable lightweight materials and ventilation methods.

Note that:

- some constraints lead to areas of consideration and some considerations are very important; therefore, it is unnecessary to separate them; they may be listed under the one heading
- constraints and considerations are very specific to the particular needs of the design situation – they are not vague or general.

Reminder for Unit 3: check the Assessment Criteria to see how your design brief will be assessed. They are published in the *VCAA Bulletin* in February each year.

The product design factors are aspects that influence design. They will be mentioned in the outline of the context but are largely the factors for constraints and considerations. Whether a factor is a constraint or a consideration in a design brief depends entirely on the situation. Some questions for each product design factor are given below to guide you; however, Chapter 4 goes into more detail.

Content for constraints and considerations (product design factors)

Adidas

This winter jacket has many features (secondary functions) to support its functionality

Purpose, function and context

This factor is relevant to both parts of the design brief.

What is the **context**? What is the reason for and what is the intended purpose of the final product? For example, a jacket may be needed for outdoor winter sports when the team member is both active and idle.

A product has a primary **function**, which is supported by secondary functions or features of the design. What might the secondary functions be required to do? For example, the primary function of a winter jacket is to keep the wearer warm. To support this function, it may require: secure fastenings to close the jacket; flexible, warm fabric to keep the heat in; a high collar to protect the neck; a layered zipper to keep it windproof; and perhaps pockets in which to carry objects. These could be listed as requirements such as: must be warm and totally windproof, must provide neck protection, needs to have spaces to store keys and cash, etc.

Performance and operation are relevant to the function. How is the product expected to perform? For example, a requirement of a tent would be that it stand securely in windy conditions. It would need to be reliable and of a quality to withstand strong wind. How it operates could refer to how it can be adjusted to suit conditions and its use; i.e. getting in and out, setting up and packing up under specific conditions.

Quality can be defined as 'fit for **purpose**'. What quality is expected in this product? Quality overlaps with other factors. What are the product's operating conditions, and for how long is it expected to perform its function? What are the strength requirements of the

product and how will they be met? For example, the product must be able to withstand machine washing, or must be sturdy enough to withstand the repeated stretching and bouncing it will be subject to, or must have invisible gaps in the joins. See more about quality indicators on page 17.

Size is important for the functionality and suitability of the end product. Does the product need to be a particular size? For example, a storage unit would have a requirement to fit into the room available; the bag must carry all the beach gear; or the outfit needs to be size 10 at the top and size 12 at the bottom. Size may be considered part of user-centred design, too. *See more about this factor on pages 96–102.*

User-centred design

What requirements are specific to your end-user?

Does age, mobility, financial status or living situation impact the wellbeing of your end-user/s, their ability to perform a task or to enjoy a good quality of life? Two examples are:

- An ergonomic design could be a requirement for your end-user. For example, a garment fastener must be easily reached by the wearer; or, on a cupboard, the handles must be wide enough and in the right position for a good grip.
- **Safety** is a vital aspect of any design, no matter what its purpose. Are there any safety requirements for this product? For example, the buttons must be sewn on in a very secure way for a baby's jacket; and a metal table must have rounded edges to avoid hurting passers-by. *To find out more about safety, go to page 39. To find out more about user-centred design and other parameters that might be relevant to your end-user, go to pages 96–102.*

Innovation and creativity

Does the end-user require the solution to be innovative? As the designer you may want to come up with a completely new concept that is very different to existing solutions. Does the end-user require a creative solution, i.e. a combination of unexpected elements? *To find out more about innovation and creativity, go to pages 102–3.*

Visual, tactile and aesthetics

What appeals visually to your end-user/s? What do they find beautiful (i.e. what is their aesthetic)? They might prefer a particular style, with specific shapes, proportions, surfaces, colours or textures. You as a designer might stipulate particular design elements and principles you think will appeal to end-users. *To find out more about visual and tactile design aesthetics, the design elements and principles, go to pages 103–4.*

Sustainability

Does the end-user prefer a solution with improved sustainability? Are they concerned with the source and processing method of the material/s and the production processes? Are they concerned with the overall impact of the product on environmental, social and economic systems? For example, an end-user may want the materials to be recycled (or recyclable), from a sustainable source, where workers are well-treated, and for the product to be long-lasting; or you may know that this aspect is important for typical end-users in a target group. *To find out more about sustainability, go to pages 104 and 119.*

Economics: time and cost

What date does the product need to be finished by? For example, in six weeks, or by a certain date. What is the budget? For example, 'My/the budget is $X'. *To find out more about economics, go to pages 107–8.*

9780170400336

Legal responsibilities

Does the product need to comply with a particular standard? For example, bunk beds need to comply with the standard AS/NZS 4220:1994 for construction, design and labelling; textile products must comply with AS/NZS 1957: 1998 by having a care label; children's toys need to comply with AS/NZS ISO 8124.1:2002.

All products must be safe for the user even if there is no relevant standard.

Are you required to create an original design and not infringe on another's intellectual property? For example, if manufacturing commercially, the design will need to be significantly different from any existing registered design. *To find out more about legalities, go to pages 108–13.*

Materials: characteristics and properties

What is required of the materials? What quality is needed?

Your use of materials can be restricted by cost, availability, suitability or workshop facilities. What special characteristics and properties are required? For example, 'thick stretch fabric is required'. Aim to include the characteristics and properties of materials required for a great solution. *To find out more about materials, go to Chapters 6, 7 and 8.*

Technologies: tools, processes and manufacturing methods

Are specific processes required for construction? Are certain processes necessary to achieve the quality expected? What is the most suitable finish for the product's intended use?

An explicit requirement may not be needed for this factor, as it overlaps with the quality standards expected in your solution.

In the classroom, you are restricted by what technology is available and the processes that you are qualified to carry out. You need to check that your design brief does not expect a solution beyond your capabilities and time constraints.

Other factors that may be important

Storage, transportation and installation: for a large product, you will need to consider the storage space in your workshop and how to move the product when it is finished. Some products are designed to be packed flat for minimal storage and easy transportation. For example, a storage unit must come apart for installation in the user's room.

After your teacher has approved a draft of your design brief, it is time to write it up in a more professional manner.

Setting out your design brief

Note the following:

- Your final design brief should be typed.
- The design brief should ideally fit on one A4 page.
- Give the two parts of the design brief clear headings: 'Outline of the context' and 'Constraints and considerations'.
- For clarity, have each constraint or consideration on a new line, like a list.

Design brief

Outline of the context

The outline should be just a few sentences, identifying the end-user/s, the need or problem, and the requirements for a product (in general terms only) and its intended function. Include

who will use it, plus where, how often and how it will be used. Try not to be repetitive with the information, but give a clear picture of the situation, background, climate (if relevant), surrounding environment, event or place, any special needs, etc., that make up the design problem.

Remember, don't describe the product – leave room for innovation and creativity in your design. Avoid adding constraints and considerations into this section as it leaves less room to explain the context and doubles up the information.

Constraints and considerations

Give each requirement a new line and use complete phrases or sentences.

Include these essential factors:

- functional and aesthetic factors
- material requirements
- quality standards
- due date
- budget
- any other relevant product design factors.

Remember, this list should not refer to design possibilities; these will be worked out later in the design process.

Reminder for Unit 3: check the Assessment Criteria to see how your design brief will be assessed. They are published in the *VCAA Bulletin* in February each year.

Indicating quality

In Outcome 3 of Unit 3, when developing your design brief you are expected to indicate the quality you are aiming for. Consider the quality to which the product should be constructed and finished. It is not sufficient to say 'good quality' or 'high quality' – you must identify the aspects that will contribute to the quality of your product and its appearance.

- **Example 1: A timber product** – it may require loose-fitting sections to allow for movement, but other precise joints for stability. If the budget allows, timber could be chosen to minimise warping and the number of faults and knots. The joints could be expected to have no gaps greater than 0.5 mm. Everything may need to be square and level. The surface may be left deliberately marked or gouged, or it may be finely sanded, using increasingly fine-graded sandpaper, to a mirror-like finish. Perhaps the product is only needed in the short term and therefore the construction does not need to be of high quality, but could be more suited to the material being used.
- **Example 2: A garment** – the material may require a certain quality, for example it must drape fluidly. It may be acceptable to have an asymmetrical design, with exposed seams, visible overlocking and threads hanging. Or it may require a traditional tailored finish with perfect symmetry in all aspects, e.g. all seams must be straight and top-sewn exactly 3 mm from the edge. All seams should have no missed bits or bunching up. Sewing thread must be of a similar colour (or contrasting!); all loose threads cut; the neckline would normally need to be symmetrical, collar and cuffs a mirror image; and the garment should usually be ironed.
- **Example 3: A toy with moving parts** – all joints must be accurate with no gaps, and all parts must move smoothly. There must be no small parts less than 35 mm that could dislodge.
- **Example 4:** any **3D printed parts** must look realistic and their finish must be smooth.

These are examples of quality indicators that you need to specify in your design brief. Later you will develop quality measures as part of your planning to achieve this quality. Check the current Assessment Criteria regarding this.

9780170400336

Example of an annotated design brief

The product is not defined in detail, leaving room to explore ideas.

Chris's problem or need is clearly defined.

Constraints typically include the words 'must', 'should' or 'needs to'.

Both constraints and considerations are in complete phrases or sentences.

This design brief includes six of the product design factors.

Design brief (for an end-user)

Outline of the context

My 25-year-old friend Chris is enthusiastically involved in a number of sporting teams. He is totally disorganised in storing and organising his sporting clothes and equipment. He needs a solution to contain the different clothing, footwear, sporting equipment and trophies he possesses. It needs to fit in his bedroom, which is not spacious. He likes 1950s retro, but edgy and interesting. He is a student with little income. His tastes and his bedroom can be seen on his profile page.

Information is given about the surrounds or design situation. This paragraph includes the 'who', 'what', 'why' and 'where'.

Constraints and considerations

Constraints are requirements that the solution must address, incorporate or abide by. Considerations are other factors that may affect the finished product or that the designer needs to research.

Function and purpose

- Must hold the required clothes, shoes and equipment
- Needs to effectively display trophies
- Needs to function appropriately (doors and drawers open smoothly, adjustable shelves, etc.)
- Size limitation – base size of 1200 × 500 mm

User requirements (ergonomics, safety)

- Stored items should be easy to reach
- Must be stable and strong

Visual, tactile and aesthetics (appearance)

- Must match the 1950s style of rounded edges and pale opaque colours that Chris likes
- Chris likes clean lines – no fussy decoration

Materials and sustainability

- Must be strong and durable, and easily maintained
- Preferably the materials should be environmentally sound, i.e. from a sustainable source, or recycled and recyclable

Economics

- Budget limit of $100
- Needs to be finished by mid-August

As the design process continues, changes in requirements can be documented in a log or journal. The design brief does not change unless its whole focus changes, which means you start again.

Areas for research and activities

In Unit 3, you are to use the design brief as a 'springboard' to direct your research and design activities. Highlighting phrases or words in the brief and annotating them will ensure that your research is relevant. The annotations should indicate what information you will research and ideas you will explore when designing. Some examples for the design brief for Chris:

- Look at the types of clothing, footwear and equipment Chris uses.
- Calculate the amount of stuff Chris owns and the current storage method and space available in his room.
- Check the measurements Chris has given me.
- Measure the trophies to be displayed.
- See how high Chris can reach.
- Research and practise some joining techniques for strength for the backs of drawers.
- Draw many ideas for handles.
- Do some trials with opening and shutting drawers quickly to see where the force is applied.
- Photograph the room and other furniture.
- Collect images of 1950s retro style furniture – shapes, materials, etc.
- Explore ideas by drawing and combining clean lines into this style.
- Look at similar storage units on the market.
- Test some functional ideas with miniature models.
- Investigate availability of environmentally friendly materials, their suitability and costs.

UNIT 3

These come directly from the design brief (can be identified and highlighted) and can be presented in graphic organisers to assist you in the design process. Other research areas may arise during the design process.

9780170400336

Developing evaluation criteria

Evaluation criteria come directly from the requirements and the product design factors that are included in your brief, and are written as questions. They emphasise what is important. Although written early in the process, they are used later on for these reasons:

- to help focus the designer on the requirements of the problem when designing
- to apply to the design options to assist in selecting the preferred option
- to apply to the finished product to determine whether or not it has provided a satisfactory and quality solution to the design problem. At this finishing stage, you will write an evaluation report and the evaluation criteria will prove their worth.

As mentioned above, evaluation criteria should not appear out of the blue and they must reflect the requirements in the design brief. If you discover new constraints (aspects that are important to the situation that you hadn't considered), then go back to your design brief and add them.

Writing evaluation criteria may seem like a repetitive exercise (that's because it is!), but it is important to see the flow of crucial design requirements through the whole process – from design brief, research and design development through to product evaluation.

Five or more evaluation criteria can be applied to the design options and at least seven to the finished product.

Evaluation criteria for design option drawings

Evaluation criteria for the **design options** are easy to formulate if you remember they will be applied to drawings. They will help you choose the most suitable solution to your brief from your design option drawings. You will use most of the same criteria as for the finished product but some will not be answerable from a drawing, e.g. Did I meet the budget? Does it fit the user? Is it finished professionally? These criteria relate to aspects assessed *after* the product has been made; therefore, they are not suitable for drawings.

Evaluation criteria for the finished product

Evaluation criteria for the **finished product** are easier to formulate if you remember to aim them at the solution, i.e. what you expect of the finished product.

You can use the same list of criteria questions for both selecting the preferred option and evaluating the finished product, or formulate two lists, as suggested on the following page for Unit 3.

Evaluation criteria in Unit 1

To find out more about redeveloping a product in Unit 1, go to page 254.

- Have an evaluation criterion for each of the differences required in your redeveloped design (from the existing product).
- Ensure that at least one of these relates to improved sustainability, i.e. how you will lessen the negative impacts of the existing product.
- Include one that evaluates whether the improved sustainability makes the product suitable for the 'new' situation.

UNIT 1

9780170400336

Evaluation criteria in Unit 2

Evaluation criteria are needed for each individual team member's production, and several evaluation criteria are used by the team. Include at least one evaluation criterion for each of the following:

- the historical/cultural design movement or style researched, and any inspiration it provided for the group product/s
- user-centred design factors and how well they were researched and incorporated into the product's (or products') design
- the sustainability of the group product/s.

Note that the requirements for Units 1 and 2 are not as strict as those for Unit 3. However, if you intend completing Units 3 and 4, it would be advisable to follow the instructions for Unit 3 as preparation. *To find out more about collaborative design in Unit 2, go to Chapter 10.*

UNIT 2

Evaluation criteria in Unit 3

In Unit 3, evaluation criteria for the **design options** can be worded in this manner:

- Does this design option show influence from ...? Or incorporate the style of ...?
- Can this design option be ...?
- Are the materials proposed in this design option suitable for ...?
- Will this design function as ...?
- Are the proposed construction methods in this option of suitable quality for ...?
- Is this design option suitable for ...?

Evaluation criteria for the **finished product** will be addressing the same factors but the questions (the first part) can be worded in this manner:

- Does the finished ... (garment, unit, furniture, etc.) show influence from ...?
- Are the materials used in the ... (name of product) suitable?
- Does it function as expected by ... (holding the contents, fitting the user, etc.)?
- Is the finished ... (name of product) made to the quality outlined in the brief?
- Were the methods used in constructing the product effective/accurate?
- Was the ... (name of product) finished by the due date?
- Was the ... (name of product) made within the budget?

These questions (addressed to the finished product) make up the first part of the four-part evaluation criteria.

UNIT 3

Four-part evaluation criteria for the finished product

The examples below are for the product in the annotated design brief on page 18.

	Explanation of parts	Examples
Part 1: Evaluation criterion	Written as a question that asks if a requirement of the design brief has been achieved.	*Does the storage solution fit easily into the space allowed in Chris's room?*
Part 2: Justification/ relevance to the brief	Why is this requirement in the design brief? Explain why it is important, why it was chosen, or what would happen if the product didn't fulfil that criterion.	*There is limited space in his room. If the storage unit didn't fit into the space allowed and had to be put elsewhere, there wouldn't be easy access to clothes and equipment.*

9780170400336

	Explanation of parts	Examples
Part 3: Ways to achieve this	Strategies for achieving the criterion during the design and production stages should be outlined (i.e. to do in the near future).	*I will carefully measure the available space, and note how much extra space existing doors and drawers take up when opened.* *I will test several timbers for strength for the shelves.* *I will research ideas for storage in small spaces.* *I will explore several of my own ideas for good use of space.*
Part 4: How the finished product could be tested or checked	A method of checking the finished product to see how it satisfies each criterion. Checking methods are suggestions for ways to see if and how your finished product satisfies the criterion; they help you to write your evaluation report. They must be specific, measureable where possible and written in a clear and complete sentence.	Suggestions for checking a variety of criteria are: • Test the product for strength or performance or to simulate conditions of use. • Run trials in which an end-user uses the product as intended; observe them using it and see how it works. • Show others and get their feedback on its appearance. • Measure it up; fit or try it on; try it out to see if it holds the items it was designed for. • Inspect joins for quality. • Feel for sharp edges/corners. • Total up costs. • Note the date when it was finished. • End-user discussions to obtain feedback/opinions.

Suggested table for four-part evaluation criteria

No.	Evaluation criteria	Justification	Ways to achieve this	Checking method on finished product
1				

Workbook DFT: Product evaluation

Reminder for Unit 3: check how your evaluation criteria will be assessed. The Assessment Criteria are published in the *VCAA Bulletin* in February each year. *To find out more about how evaluation criteria are used when the product is finished, go to page 263.*

Research

Information–gathering is vital in idea development and throughout the design process. Your research can also give you inspiration – not only for current trends and styles, but for clever solutions to design problems.

Areas for research might include:

- measurements related to your design problem
- a survey of typical end-users of your product
- relevant ergonomic information, such as average height and reach of the general population for a storage unit
- interesting use of materials, availability and cost of materials, properties and characteristics of materials, sustainability of materials, how they can be used and their correct names
- inspirational pictures of similar solutions to design problems, images from nature, and patterns and textures
- interesting design features in different products that could be incorporated into your designs

9780170400336

- innovative solutions for functional problems
- observations and/or photographs of an end-user in action or in the place where the product will be used
- historical information (early examples of similar products)
- work of specific designers, styles or movements
- design principles and elements that could suit the end-user
- possible construction and decorative techniques, photographs or samples of skill practice
- components, fittings, notions and finishes that could be used, costs and suitability.

To find out more about design elements and principles, go to page 74.

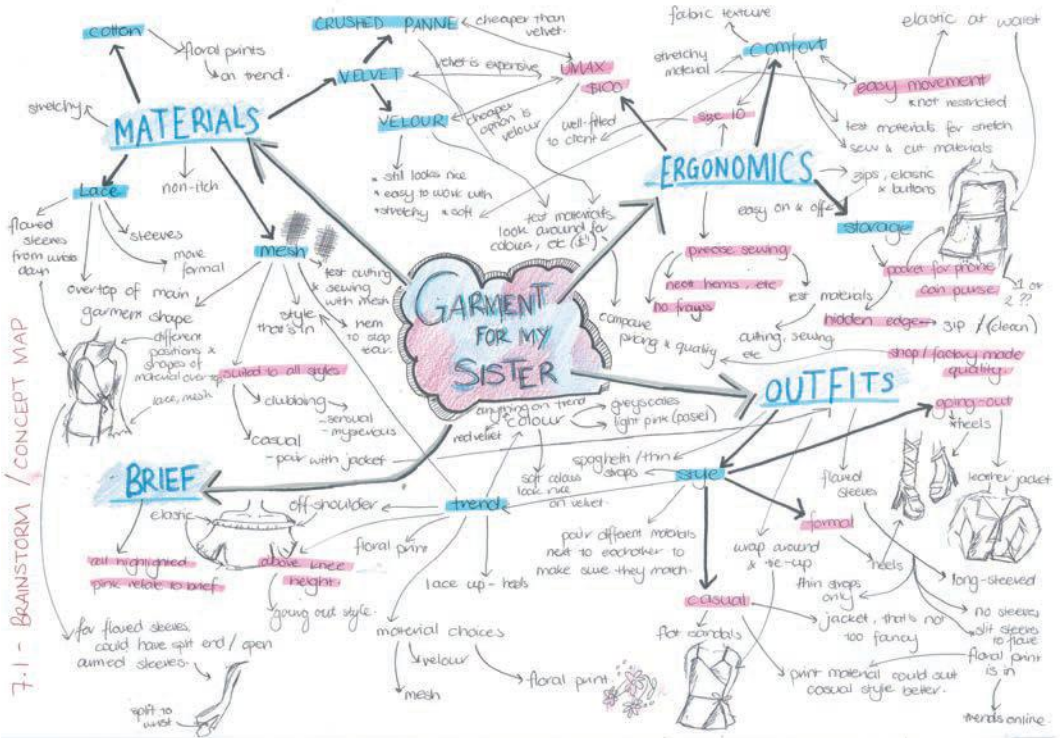
Graphic organisers to plan and manage research

If you included or highlighted a list of areas to research in your design brief, you might like to organise and present these visually, using graphic organisers.

Examples of graphic organisers are:

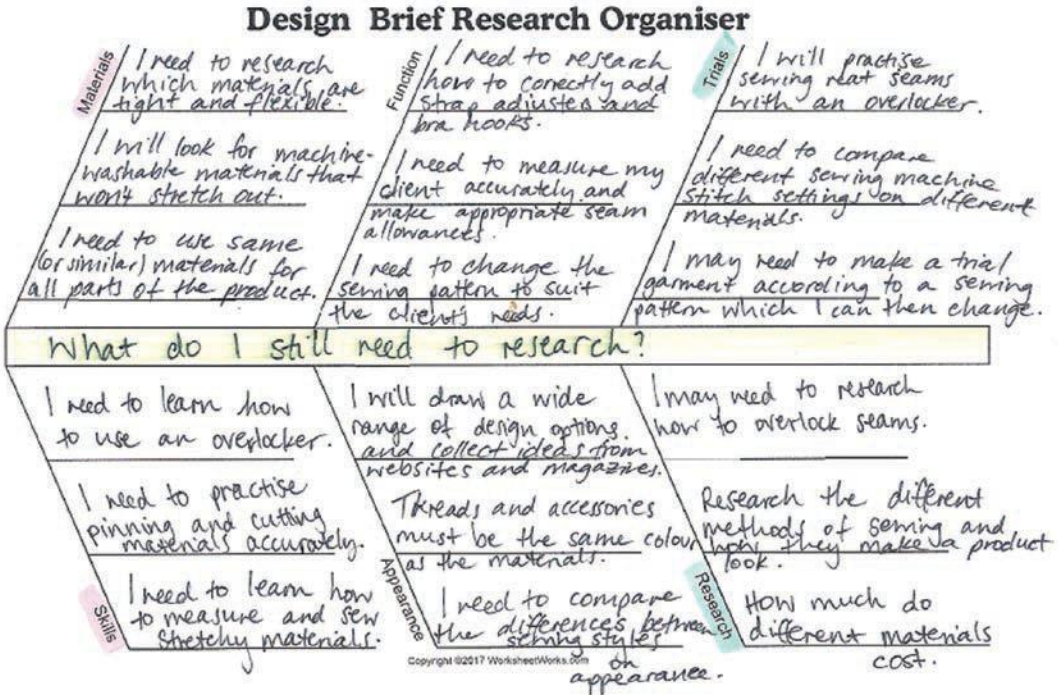
- fishbone diagrams
- spider maps
- lotus diagrams
- Venn diagrams
- concept maps
- star diagrams
- pie charts
- PMI charts.

Any of these methods can be combined, and colour and images can be added for visual interest.



A concept map, by student Paige Anderson

For examples of a wide range of graphic organisers, go to the Enchanted Learning website and select 'Graphic Organizers' from the side panel. Or go to Worksheet Works and click on 'Miscellanea', then 'Graphic Organizers'. Links to these websites can be found at http://nelsonpdtvce.nelsonnet.com.au.



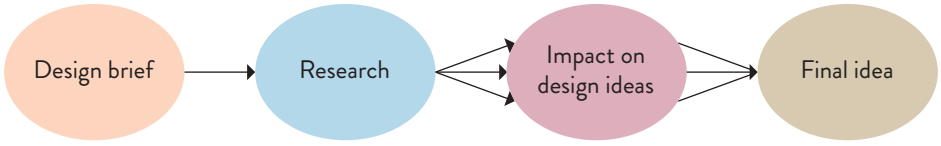
A fishbone diagram for a garment by student Greta Hollows

How much research to include?

Research should not be 'busy work' – it should be targeted and have a clear purpose or answer a specific question. You should always be able to make a connection from your design brief to your research, and then to the impact it has on your designing. *Read 'Annotation of research' on page 28 and 'Divergent and convergent thinking' on page 53.*

Make connections

Show the links from the design brief to research, and research to design drawings and solutions in your annotations.



Remember that research is about gathering and processing. While it is appropriate to download or photocopy relevant information, you should limit the amount of text from secondary sources that is placed into your folio. When you do so, you should make it clear where the text has been sourced from. You can highlight areas and/or write your own comments in the margins. Avoid rewriting large amounts of data. Wherever possible, pick and choose only relevant information and present it in your own words. Use images to illustrate information.

When it comes to inspiration, aim to include images of things other than alternative versions of the intended product. For example, use an artist's work, mathematics, architecture, animals, plants or nature to inspire. You can see examples throughout this book.

Inspiration from a different field

Many designers are inspired by the work of artists. Examples are the many products inspired by the painter Piet Mondrian (1872–1944).

Alamy Stock Photo/INTERFOTO

Wikimedia Commons

In 1965, Yves Saint Laurent, French fashion designer for Dior, created dresses directly influenced by the work of the 1930s painter Piet Mondrian (right). The dresses were made of wool and silk with graphic thick black lines separating blocks of colour.

Shutterstock.com/Marko Bradic

Wooden *Red Blue Chair* by Gerrit Rietveld (1923), inspired by Mondrian

Fashion house Valentino also searches globally for fresh ideas. *See how Valentino used the work of Christi Belcourt on page 285.*

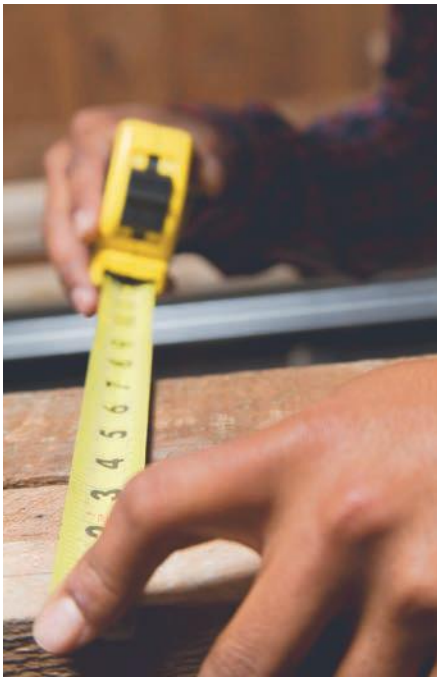
Make sure that you acknowledge the designers of any inspirational design work in your research. Methods and suggestions on how to be creative are covered in Chapter 3.

Research from primary and secondary sources

Comprehensive, worthwhile research involves many techniques and resources from both primary and secondary sources.

Primary sources of information

Primary sources are obtained first-hand, that is, from your own activities. These include observations (which can be photographed or filmed), testing, measuring, weighing, collecting material samples, trialling construction techniques on samples, taking photographs, carrying out surveys, and discussions with potential product users or users of similar products, etc.



iStockphoto.com/alejandrophotography

Primary sources of research are obtained first-hand, e.g. from observing or measuring

Secondary sources of information

Secondary sources are published accounts of information supplied by others – it's when someone else has done the research for you. These include magazines, books, journals and the Internet. Typically, information on ergonomics and materials would come from secondary sources. Remember that information from secondary sources is not your own work, so don't overdo the amount that you place in your folio and always include the source (and date if it is from the Internet).

Gaining input from many sources promotes flexibility in your approach and helps broaden your knowledge before you start designing.

Reprinted with permission of Skills Publishing Pty. Ltd.

This *Australian Woodworker* magazine is an example of a secondary source of research

Presenting numerical research visually

Sometimes, numerical data does not mean very much to people and is difficult to decipher. Presenting statistical information in a pictorial manner enhances understanding. Bar charts, line graphs, block charts and pie charts are commonly used for clear communication.

For example, imagine you had to design a locker for your class or school. You could conduct a survey to find out what most students wanted to store in their locker, such as:

- pencil case
- large books (e.g. textbooks)
- small books (e.g. novels)
- clothes
- sports gear.

The statistical results of their responses could be shown in a number of ways. Compare the same results on the following page – presented in a table, a pie chart, a bar chart and using other methods. It's easier and faster to decipher the two charts than the table because the information is presented visually.

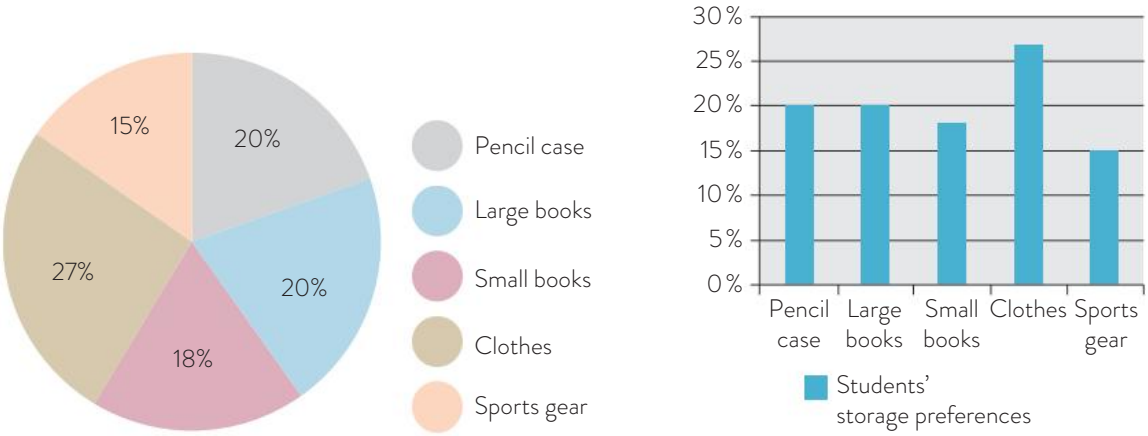
Information that can be presented numerically (in numbers) is called **quantitative** data, as opposed to **qualitative** data, which is descriptive.

Survey results in a table

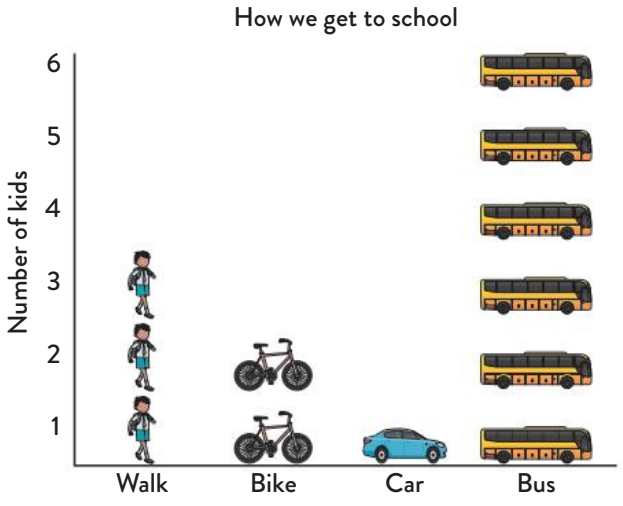
Pencil case	Large books	Small books	Clothes	Sports gear
20%	20%	18%	27%	15%

Survey results in a pie chart or bar chart

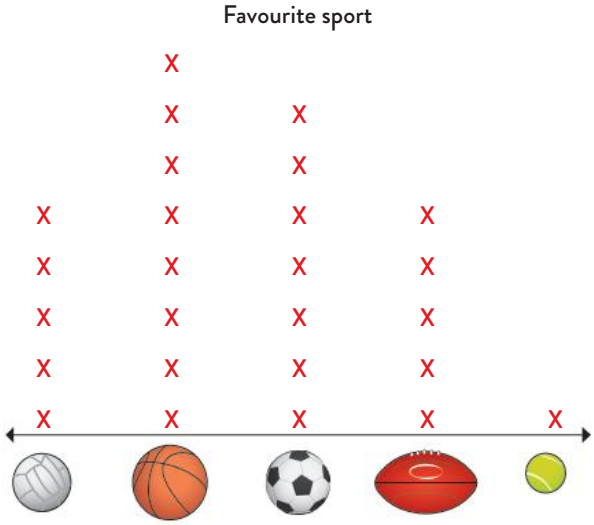
Pie charts give a clear visual picture of the information and can be hand drawn or produced on a computer for accuracy. Bar charts are another effective way of presenting information visually. Pictographs are also effective, as shown below.



A pie chart of the information 'Students' storage preferences'; a bar chart (right) presenting the same information as the pie chart (left)



A pictograph comparing methods of getting to school



A line plot of favourite sports

Go to Data Viz UK 'Improving data visualisation for the public sector' for lots of ideas on presenting information visually.

The Tech Republic website has tutorials on how to 'Use Excel to create simple graphs'.

Links to these websites can be found at http://nelsonpdtvce.nelsonnet.com.au.

9780170400336

Images or samples of materials

If you include samples or images of materials, be sure to name them correctly:

- For fabric, include the fibre content and the weave, e.g. 100% silk chiffon.
- For timber, include the botanical name of the tree species if possible.
- For metal, give the full name.
- For plastics, provide the full chemical name.

Annotate why you have them in your folio. Avoid including images of materials that are unobtainable or have no relevance to your project.

Attributing intellectual property (IP) and acknowledging your sources

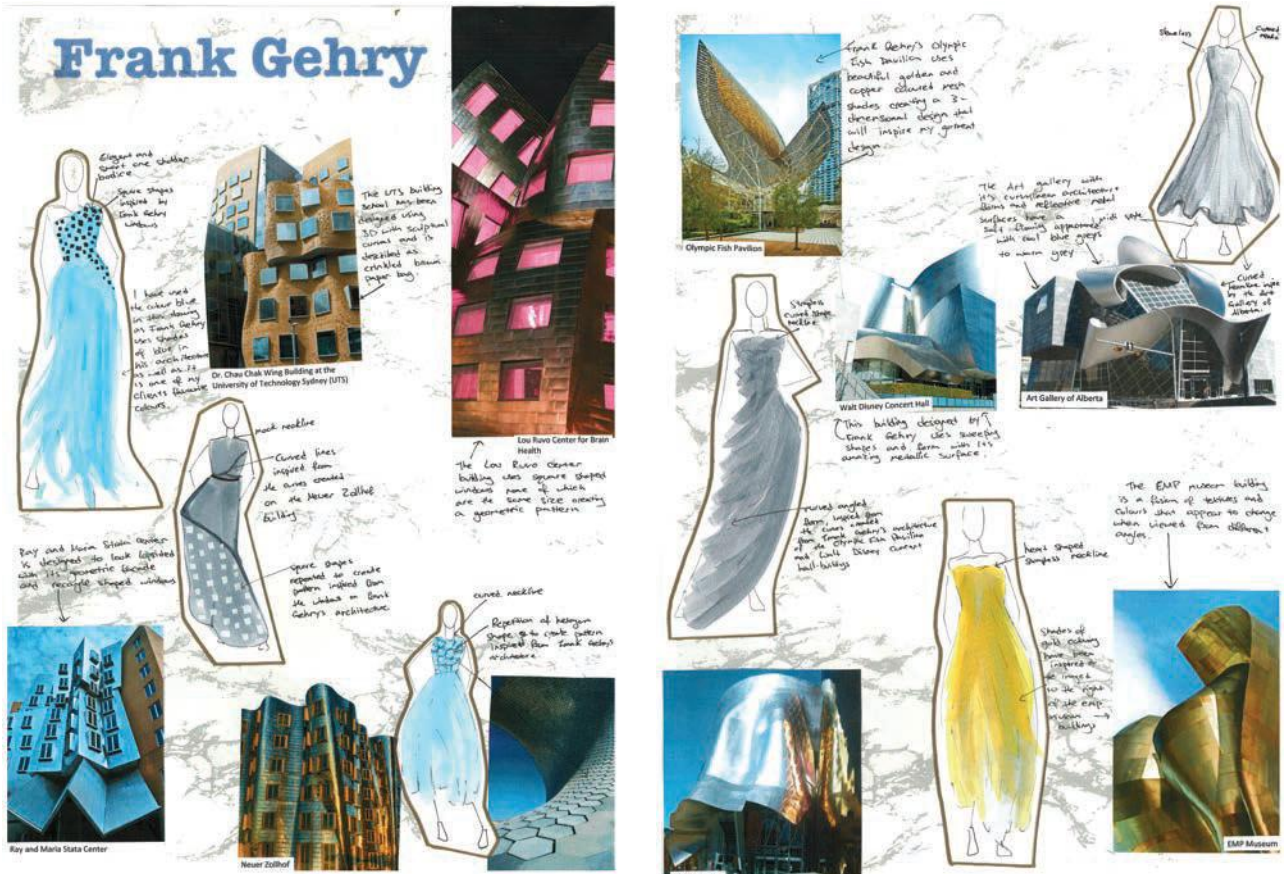
It is important that you acknowledge the sources of the information in your folio. Cite the author and/or the title of each text and, if it's from the Internet, include the URL and the date you accessed it. In this subject it is best placed near the information.

Attributing the IP of the work of others means including the creator's name in an obvious way near the image. If the designer's name is not clear, then give the company's name. Note that Google Images, Pinterest and other image-collecting sites are not the creators of the work they display.

To find out more about IP, acknowledgement, copyright and moral rights issues, go to pages 108–12.

A Reminder for Unit 3: check how your research will be assessed, which is usually according to its relevance to your design brief and impact on your idea development, and how you can show the link. The Assessment Criteria are published in the *VCAA Bulletin* in February each year.

UNIT 3



Annotated research and ideas with IP attributed to the architect Frank Gehry, by student Demi Spyropoulos

9780170400336

Annotation of research

annotate to write a comment, with arrows to indicate links and aid communication

In Units 3 and 4, you need to indicate why you have chosen to include images or information in your research section. Remember to relate it back to the design problem. **Annotate** the parts of your collection that inspire you, such as the use of contrast, particular shapes, colour combinations or even moods that the research evokes. Annotate other research to explain how you will use the information when designing or to explain how it relates to your end-user.

UNITS 3&4

2 DESIGN AND DEVELOPMENT

design and development developing multiple ideas into one final design

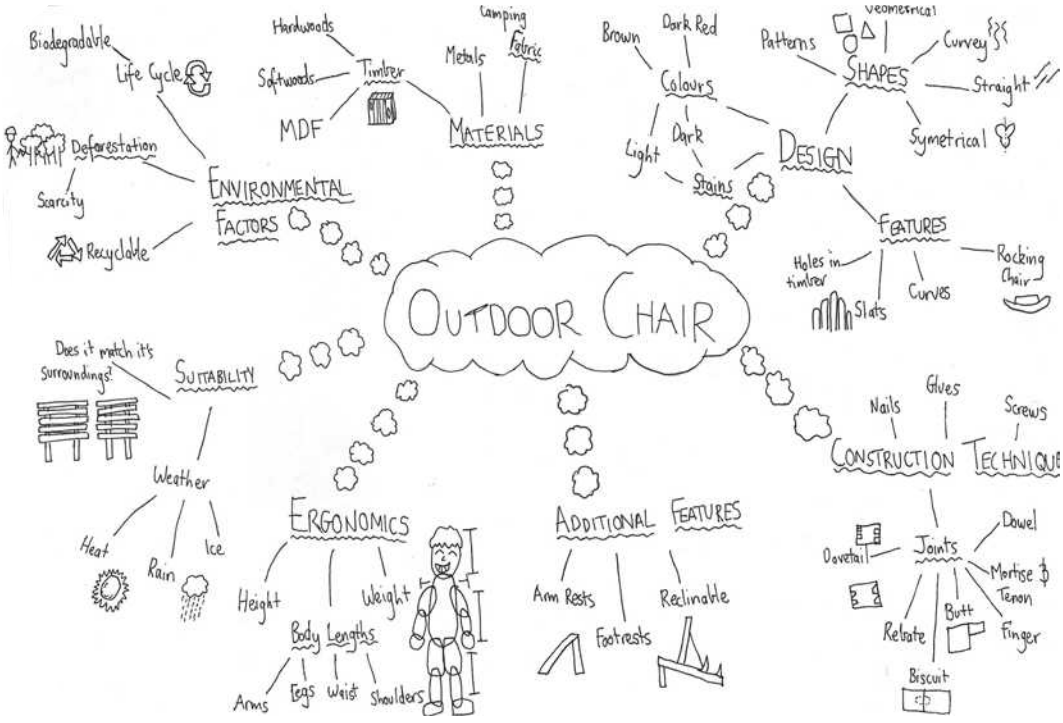
Design and development (conceptualisation) is the second stage of the design process, where ideas are conceptualised and formulated. It could well be termed the 'where do I start?', 'what might work?' and 'what are my decisions?' phase. This stage requires both critical and creative design thinking.

The following information explains briefly the types of drawings (or modelling) expected at the design and development stage.

Methods and suggestions on how to be critical and creative are covered in Chapter 3.

Using graphic organisers

Before starting to draw your ideas, you could use graphic organisers to list the requirements from the design brief and the possible choices that are available to you. As with managing your research, you could use fishbone diagrams, spider maps, lotus diagrams, Venn diagrams, concept maps or your own method of presenting ideas graphically. Use colour and images to create interest. Always add a heading or explain what the graphic organiser is for.



An example of a concept map for an outdoor chair, by student Steven Kearns

9780170400336

Types of drawings and their purpose

In this study there are certain types of drawings expected throughout the design and development stage of the product design process. Drawing types are:

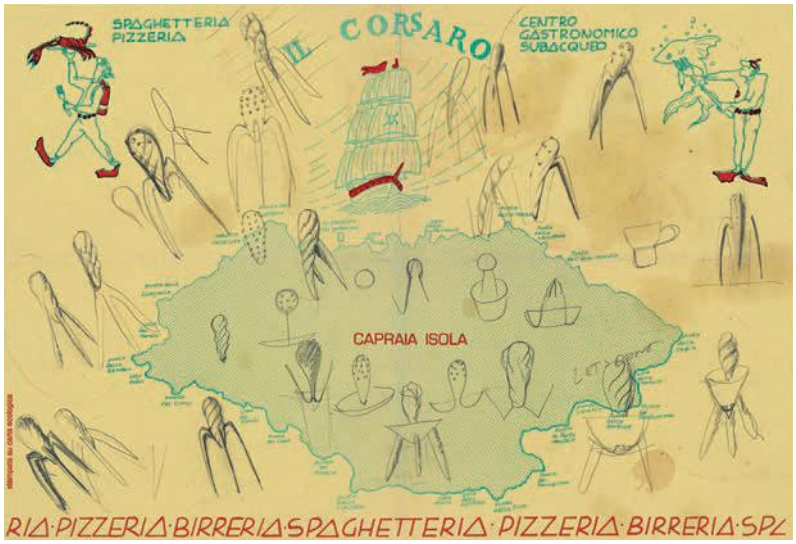
- **visualisations** – quick sketches, mostly small, to nut out and develop ideas and to show links or influence from research (*pages 59 and 69*). Note that visualisations can also be in 3D form, such as models or mock-ups
- **presentation drawings** – to clearly show the whole product rendered and in 3D for design options and the preferred option (*pages 61 and 69)*
- **working drawings** – to show all the information needed to construct the preferred option (*pages 63 and 71*).
  Go to Chapter 3 to find out more about appropriate drawing styles for different stages.

Visualisations: for idea formation

Drawings that are suitable for **visualisations** are often called thumbnails or concept sketches. They are drawings used to 'get down' your initial ideas and are usually completed quickly and without too much detail or accuracy. Often, students prefer to work with lead pencil, but this work can be brought to life if colour, black outlines or other media are used somewhere on the page.

visualisations representations of potential ideas for the whole, or components, of your design

Record your ideas as soon as you have them. Philippe Starck's first ideas for the famous *Juicy Salif* (a juice squeezer) were drawn on a placemat from the restaurant he was sitting in at the time. It's easy to forget those ideas that come from moments of inspiration unless you record them immediately. Great drawings on scrappy paper can easily be pasted into a folio page.



Philippe Starck Network

Alamy Stock Photo/Mouse in the House

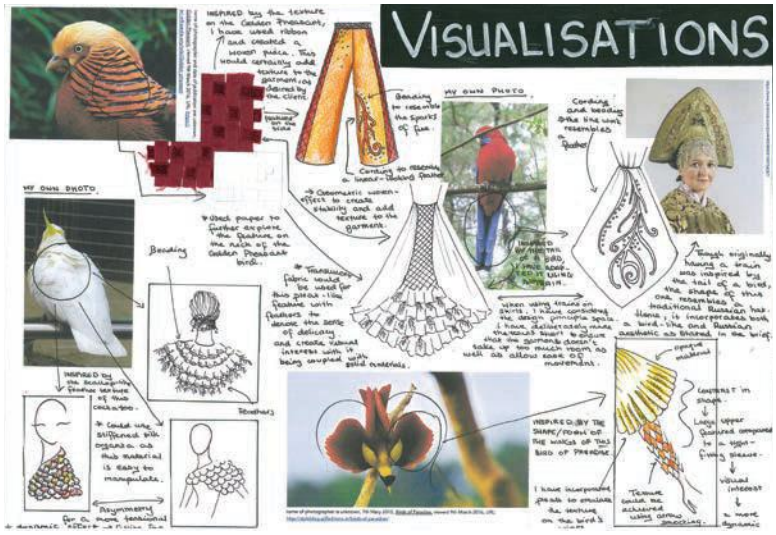
Philippe Starck's *Juicy Salif* for Alessi began with sketches on a restaurant paper placemat

Visualisations should be drawn near the researched images that inspired them. Fill two to eight A4 pages in your folio. Use annotations with arrows to show the links, to explain where your design thinking is heading and to critically analyse some of your ideas. Quick 3D models (e.g. cardboard, fabric) and mock-ups are another method to visualise ideas (take photos and add to your folio with annotations).

Towards the end of your visualisation pages, some of the ideas may start to become more complete as you get selective. These don't need to be drawn next to your research. You will apply **critical thinking** techniques, such as comparing against the design brief requirements, using evaluation criteria questions, identifying advantages and issues related to ideas, and PMI reflections, to isolate the best and most achievable ideas. All of this thinking should be shown through your annotations.

critical thinking involves a variety of techniques to analyse and make the most suitable decisions

9780170400336



Annotated visualisations among research and own photos, by student Lian Wilson (left); visualisations with research for a Venus fly trap costume, by student Sarah Luisi (right)

Presentation drawings: for design options

presentation drawings detailed 3D drawings that show the whole product and are used to convey a fully worked out design solution

Presentation drawings are used to represent design options (and the preferred option). They are larger, show the whole product and have more detail and accuracy than visualisations. Presentation drawings draw on the most suitable ideas from the visualisations; they give a very clear picture of the proposed design. Many different media can be used in these drawings to give them impact, such as dark pen for outlines; paint, markers or pencil for colours and to render tone and texture; and paper, fabric or photographs to simulate texture. They can also be created or enhanced with the use of suitable software (CAD).

When preparing your presentation drawings, note the following points:

- Each design option should fulfil most of the evaluation criteria but in a different way, i.e. design options should not be almost identical designs with only slight variations.
- They should be clearly numbered and presented on one or two pages (A4 or A3).
- They must be annotated to show your design thinking.

Ask your teacher how many options are required in Units 1 and 2, and what you are expected to annotate.

UNITS 1&2

In Unit 3, between three and six options are required. Quality and detail, including exploration of the visual, tactile and aesthetic parameters, are more important than quantity.

You can find many excellent examples of design options in the Top Designs catalogues produced every year by Melbourne Museum.

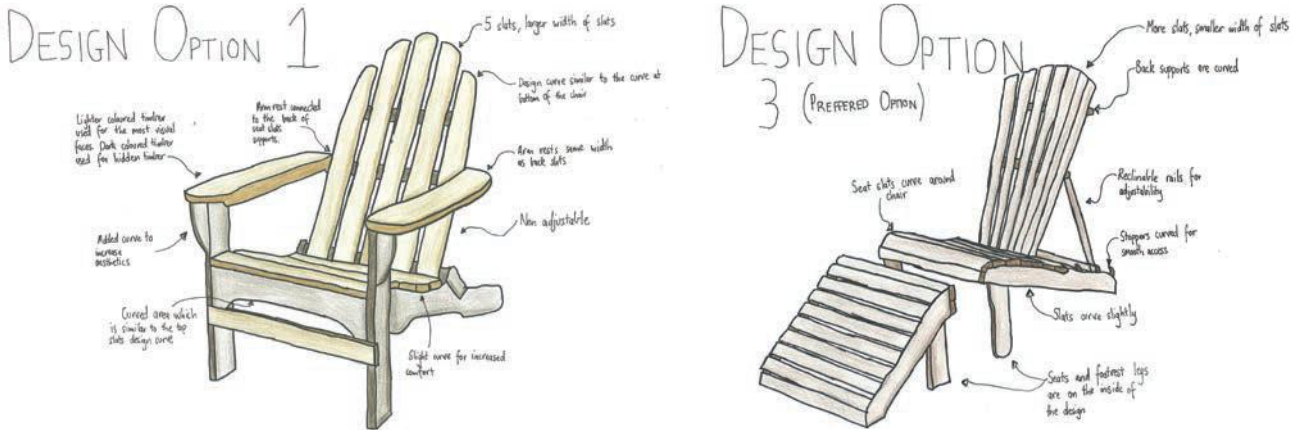
UNIT 3

Annotations

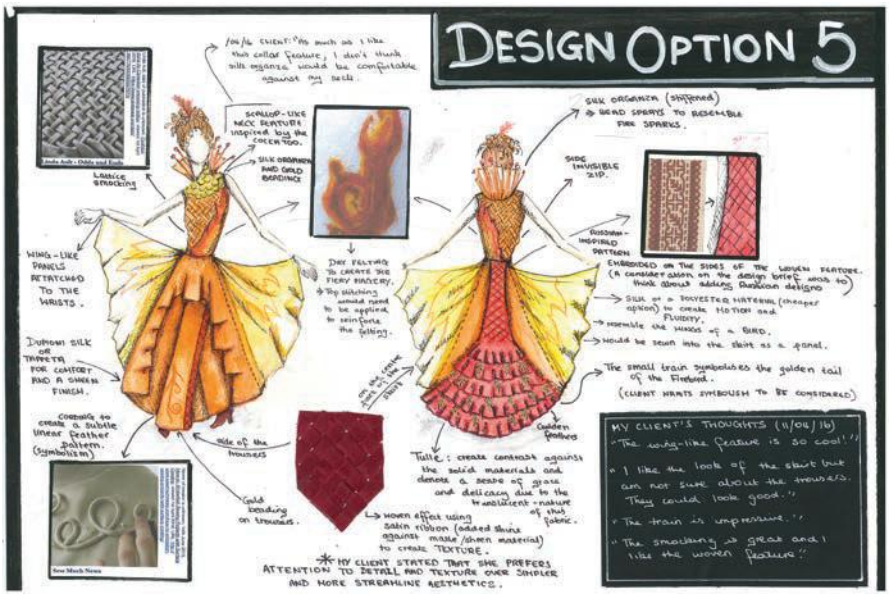
Annotations are required on design options to show your design thinking and decisions. They should be clear and detailed, using phrases and sentences, and cover a range of areas such as:

- how different aspects of the design fit the requirements of the design brief (how it works, how it suits the client and the situation, etc.)
- where you got your ideas from (this relates to your research)
- proposed construction processes (e.g. zipper placement, type of joins) or details that can't be seen
- proposed (possible) materials to be used
- significant design features
- how the design addresses the relevant product design factors.

9780170400336



Annotated design options for a chair, by student Steven Kearns



Annotated design options, coloured and clearly numbered, with materials samples and user feedback, by student Lian Wilson

9780170400336

Using evaluation criteria is a critical thinking technique.

Selecting the preferred option

After you have presented three or more design options, it is time to apply the evaluation criteria and select the best one. This will be called the preferred option. You may find that the best solution to the design brief is one of your design options, or an option with a few modifications, or a combination of ideas from several design options.

Workbook DFT: Design options scoring grid

Feedback from others

In Unit 1, you select the preferred option yourself, but feedback from others is always useful. Remember, your redeveloped product must somehow improve the product's sustainability and must be significantly different from the original product.

In Unit 2, you must get feedback from your team members to select the preferred option. Aim to record at least one comment from each of them. This is important whether you are working on individual products in a range, or if you are all contributing to one product.

Check with your teacher if you need to include the following grids and justification outlined for Unit 3.

UNITS 1&2

Workbook DFT: End-user feedback log

In Unit 3, when deciding which option is the best solution to the design brief, feedback from an end-user is crucial. While discussing each option, you may discover more information about what an end-user wants or needs. It is important to get feedback and not assume you have thought of everything. Their feedback may surprise you. Always write down the feedback comments (see the suggested grid with the next heading). Where possible, you should aim to get feedback from more than one person, particularly when designing for a target market. They may come up with one small thing that inspires you or even changes your whole design direction.

UNIT 3

Applying the evaluation criteria to your design options

A systematic method of selecting the best option is to apply the evaluation criteria to each drawing, score them out of five, add end-user feedback and total up the score. You can do this in a little table or grid, placed close by each option.

Take the evaluation criteria you wrote earlier (*see pages 19–21*), copy them, reduce the font size, and place into a small table with two extra columns. Copy one grid (table) for each option. While a scoring method is not mandated, it will help you to select and justify the preferred option. Score each option with an/the end-user.

Here is an example of a small grid to place near each option:

	Evaluation criteria	Score	End-user feedback for Option 1
1	Are the proposed materials in this option suitable?	/5	
2	Does this option show …?	/5	
3		/5	
		/5	
		/5	
Total score for Option 1		/25	

decision matrix a decision-making tool that rates options and collates the scores for easy reference, when comparing them against criteria for a situation

Using a decision matrix (optional)

While a **decision matrix** is not required, it can help to determine the highest scoring option. A decision matrix can be presented as on the following page. It collates and compares the results for all options in the one table.

Decision matrix comparing options for builders' eye protection

Criteria applied to all design options	Design Option 1	Design Option 2	Design Option 3
1 Will it provide adequate UV protection?	5/5	3/5	0/5
2 Will it be comfortable to wear?	3/5	3/5	4/5
3 Are the proposed materials strong and scratch-resistant?	3/5	4/5	5/5
Totals	11/15	10/15	9/15

From the decision matrix above, you can see that Design Option 1 did not fare so well for comfort and scratch resistance, but scored the highest overall due to its 100% UV protection. If several of your designs have the same score (or none of your designs rate well!) it may be time to 'go back to the drawing board', combine the high-scoring aspects and develop another or further options. Highlighting the column with the highest score is a good visual way to communicate the results.

Justifying the preferred option

When **justifying** the preferred option, you can refer to each evaluation criterion and explain how it is evident. Use the comments that you applied to each option in the column titled 'End-user feedback' from your grids to help you.

justification a written statement explaining your choice

A good example would be a paragraph, no more than half an A4 page, like the following:

> Mr Clark (the end-user) rated Design Option No. 3 the highest with a score of 36 out of 40. It was an easy and immediate decision. He liked the type of joints I had drawn for the table legs –mortise and tenon – as he said that would give the table strength. Strength was one of his most important requirements. He also liked the slightly tapered leg design I had drawn. This was also rated as 'high', because he likes French provincial style and the tapered leg is typical of this style. The height and size wasn't an issue because I made all my design options fit the measurement constraints, as they were also heavily weighted criteria. Mr Clark preferred the slightly rounded edges of the tabletop, because he has small children.

Reminder for Unit 3: check how your design options and justification of the preferred option will be assessed. The Assessment Criteria are published in the *VCAA Bulletin* in February each year.

Working drawings: for product specifications

The last step in the design and development stage, and the first major step in planning for production of your preferred option, is to complete working drawings.

working drawings mostly 2D drawings that communicate the product specifications and components

Working drawings are developed for the preferred option and are mostly 2D, but some 3D drawings can be included to indicate the way the piece will look. They communicate the product specifications – shapes, sizes/measurements, components and construction methods – to construct the product. They indicate the placement of components; known as attachments, fixtures, fasteners or notions (textiles).

- Technical drawings are for resistant materials (i.e. wood, metal, plastics and/or industrial ceramics). See below.
- 'Flats' (or flat sketches) are for non-resistant materials (i.e. textiles).

The thinking and detailed planning involved in producing these drawings reinforces your knowledge of your design. It is important for calculating the steps in production and the materials required.

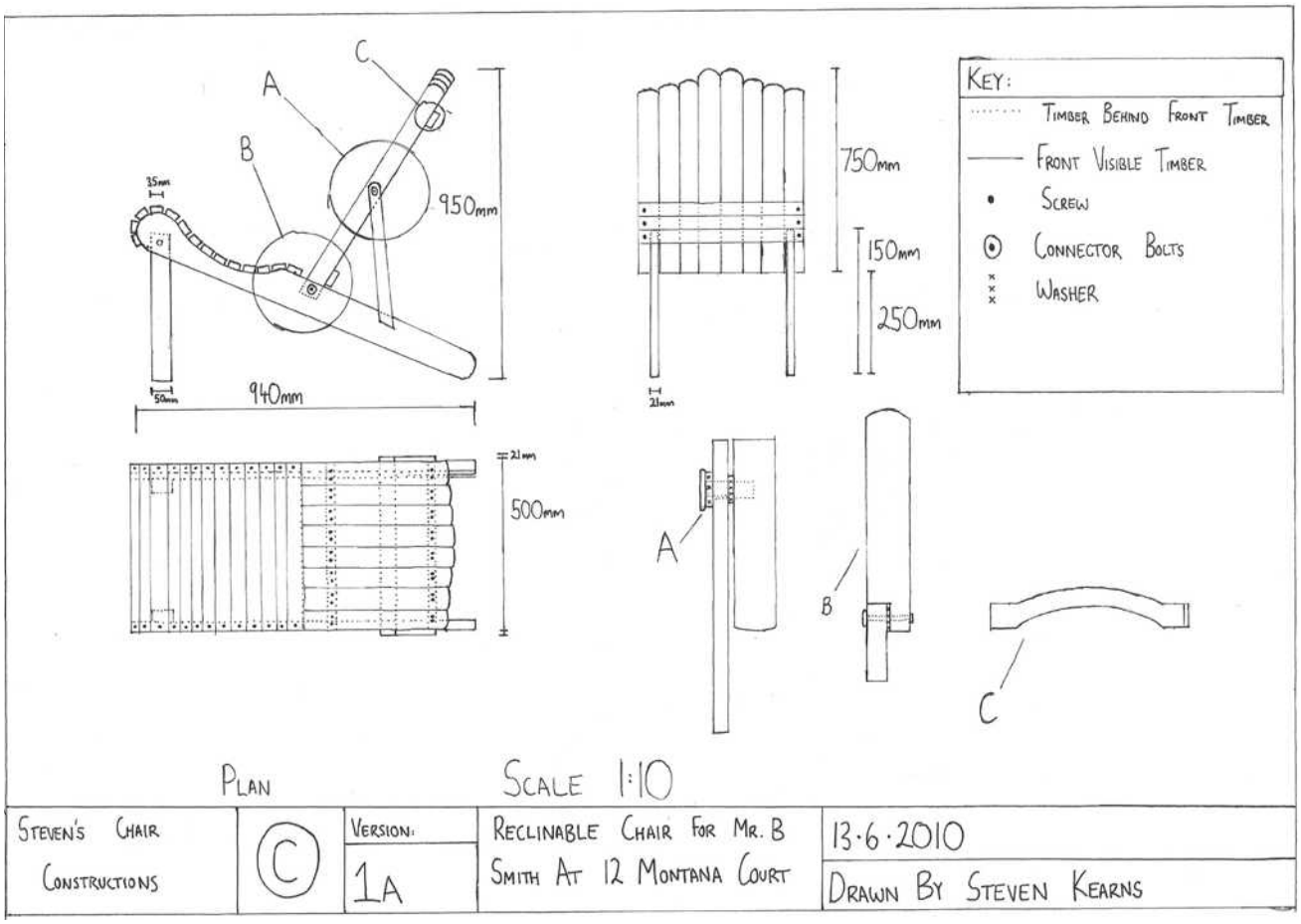
For more information on the design and development stage and different drawing methods, go to Chapter 3.

Technical drawings for resistant materials

Resistant materials are wood, metal, composites and most plastics

Suitable 2D working drawings for resistant materials are orthogonal drawings or elevation views. Template drawings may also be required later in production to cut accurate shapes. Each view (or drawing) should be clearly named, particularly for drawings of details or smaller parts.

Suitable 3D drawings would be in the form of (cabinet) oblique, isometric or perspective.



2D elevations, plan views and details of an outdoor chair for Unit 3, by student Steven Kearns

'Flat' drawings for non-resistant materials

Non-resistant materials are textiles.

A 'flat' sketch is required for garments and most other textile products. This is similar to laying out the garment flat on a table. It will require both back and front views. It also requires measurements to suit the (typical) end-user.

Pattern drafting creates all the pieces needed to construct the design from the 'flat' sketch. For production, students can use a commercial pattern, but must modify it so that it shows their design input and reflects their preferred option and its working drawing.

Pattern drafting is a highly skilled craft that takes years to perfect. It involves creating an initial template (a block) appropriate to a specific body measurement, and then shaping the template to the desired 'look' of the garment. Once checked, in a toile or mock-up, the pattern is finalised. In mass production, the pattern drafter 'grades' the pattern to fit a range of sizes by adding lines for smaller and larger sizes. Software packages are available for purchase to make this traditional hands-on task easier.

Preferred option and working drawings for a Venus fly trap costume, by student Sarah Luisi

Reminder for Unit 3: check how your working drawings will be assessed. The Assessment Criteria are published in the *VCAA Bulletin* in February each year.

You can find many excellent examples of working drawings in the Top Designs catalogues produced every year by Melbourne Museum.

Free 'flat' templates for garments that can be adapted in Illustrator can be sourced at the Designer's Nexus website. You will find many tutorials for creating 'flats' – technical garment drawings – in Illustrator online as well. A link to the Nexus website is on http://nelsonpdtvce.nelsonnet.com.au.

9780170400336

3 PLANNING AND PRODUCTION

Organising and planning for production requires considerable thought, as this third stage involves bringing together all the necessary elements to allow for a smooth flow of production work.

Scheduled production plan

The components of the scheduled production plan are:

Component	Briefly	Role
Production steps	How?	How to construct your product with a list of steps to follow
A timeline	When?	To give milestones and dates for the steps
Materials list and costs	What with?	To be prepared with all materials and bits required
Risk assessment	For safety	To look ahead and avoid accidents and incidents
Quality measures	Good job	To create the best quality work possible

It helps to start with a (predicted) list of production steps required for construction. You may feel that you don't have the skills yet, but forcing yourself to think ahead will help you be independent from your teacher. It will reinforce your existing knowledge and indicate areas where you will need help or where you will need to do some research or practice.

Production steps

sequenced plan of construction detail of steps you expect to follow to construct the product (in logical order)

Production steps are a **sequenced plan of construction** that list and describe the production processes (steps) in an order that you expect to follow. They include details of how each process will be carried out, equipment and material needs, particular safety precautions and the estimated time needed. You must identify any teacher or outside assistance required, as there may be some processes that rely on machinery or skills that you do not possess or have access to. The people concerned need to be located and you will need to make arrangements with them.

See the following page for an example of a sequenced work plan and note how the student has communicated teacher assistance. You can find many excellent examples in the Top Designs catalogues produced every year by Melbourne Museum.

Workbook DFT: Production steps template

In Units 1 and 2 your sequenced plan can be quite broad. Start by thinking about the major processes. They are included in the technologies factor and are as follows:

- preparing the material
- measuring and marking out
- cutting and/or shaping and/or forming
- joining and/or assembling (this will have several steps)
- embellishing or decorating
- finishing.

UNITS 1&2

In all units, if you think about the major processes to construct your project, you will find it easier to add more detail. Remember, a plan is a prediction, so it doesn't need to be precisely accurate – it's how you expect to make the product. The actual steps taken will be documented in your journal throughout production.

9780170400336

An example of production steps by a student for an outdoor table

Step	Process and materials	Tools/machines/equipment	Safety measures	Est. time
1	Marking out and measuring dressed cypress timber	Tape measure, pencil, tri-square, workbench		45 min
2	Cutting all legs, rails and planks for tabletop to length	Docking saw (electric)	**To be cut by Mr Ahmed**	50 min
3	Marking out the mortise and tenon joints on the top of the legs and ends of the rails	Tri-square, pencil, marking gauge, ruler		50 min
4	Drilling holes for the mortises in the legs	Bench/pedestal drill	Make sure wood is clamped to drill bench, wear safety glasses	40 min
5	Paring back mortises	Chisel, bench vice	Cut away from hands	2 h
6	Cutting out tenons on the rails	Handsaw, chisel	Use bench hook or clamp wood to workbench	2 h
7	Testing and ensuring mortise and tenon joints fit, fixing	Gentle tapping with mallet, fine work with chisel	Make sure work is secure	?
8	Use template to mark out gentle tapering shape for legs	Template, pencil, workbench		20 min
9	Shape legs and smooth off	Bandsaw Rasp, file, sandpaper, sander	**Bandsaw to be used by Mr Ahmed**	3 h
10	Joining rails to legs, checking squareness	Sash clamps, large square, tape measure to check diagonals		1 h
11	Marking out dowel joints for joining tabletop pieces	Square, ruler, pencil		30 min
12	Drilling holes for dowel joints, checking drill bit size, making sure top side of planks goes face down	Dowelling machine	Clear all debris Tie back hair and loose clothing Make sure drill bit is in correctly	30 min
13	Cut dowels for joints, making them a little shorter than the depth of the hole	Vice, handsaw	Make sure work is secure	30 min
14	Join planks for tabletop with suitable outdoor glue	Sash clamps	Fresh air to avoid toxic fumes from glue	1 h
15	Assemble table (not sure how to do this yet)	Router, metal support brackets, electric drill and screwdriver	Electrical safety	2 h
16	Sanding in gradations and treating	Sander, sandpaper, brushes, oil	Dust mask, move table outside	?
	Total hours expected			18+ h

9780170400336

Production steps for textiles

Sometimes the safety precautions in textile projects become repetitive. To avoid this, delete the 'safety' column and add a row underneath the table that lists safety precautions to be taken throughout production. Or refer to the controls in your risk assessment.

Timeline

timeline
chart showing the dates at which you expect to have different steps of your construction completed

A **timeline** shows the dates at which you expect to have different steps of your construction completed. It can be drawn as a Gantt chart a timeline commonly used in industry. Gantt charts are used for complicated projects that involve a lot of people with varied skills and require checking off. However, in VCE you can make a simple timeline or Gantt chart by using the table facility in Microsoft Word or Microsoft Excel, like the example below.

Check that the steps in the timeline match the steps in the sequenced work plan (*see page 37*). These steps can be written in an abbreviated form in the timeline.

An example of a timeline for the outdoor table

	Week 1		Week 2		Week 3		Week 4		Week 5		Week 6		Week 7		Week 8	
Steps ↓ Dates →	22 May	24 May	29 May	31 May	5 June	7 June	12 June	14 June	19 June	21 June	10 July	12 July	17 July	19 July	24 July	31 July
1 Marking & measuring	■															
2 Cutting pieces		■	■													
3 Marking joints				■												
4 Drilling holes					■											
5 Paring mortises						■										
6 Cutting tenons							■									
7 Checking joints							■									
8 Marking out legs								■								
9 Shaping legs								■								
10 Joining/checking									■							
11 Marking joints										■						
12 Drilling holes										■						
13 Cutting dowels										■						
14 Joining planks											■	■				
15 Assembling table													■	■		
16 Sanding/finishing													■	■	■	■

Workbook DFT: Digital timeline for production

You may prefer to combine the production steps and timeline in one table, but this can get rather crowded.

9780170400336

Risk assessment and management for safety

Safety is not only vital during production; it is integral to all aspects of Product Design and Technology. Many processes involve a level of risk, such as using equipment, materials and chemicals that may be harmful if used inappropriately. Products made can also be dangerous. A **risk assessment** aims to predict and eliminate or lessen incidents, possible accidents and injuries through safety controls. It occurs before production to enable **risk management**.

risk assessment predicting and measuring levels of risk and planning methods of risk control

risk management a process used to recognise hazards, manage and control risks

Textiles

The most common injuries or illnesses in textile production result from:

- poor manual handling practices
- slips, trips and falls
- musculoskeletal problems due to bad posture and repetitive movements over prolonged periods
- eye strain due to poor lighting
- inhaling or absorbing hazardous chemicals in fabric, thread and dye.

Guidelines for textiles workrooms	
Classroom/workroom	• Ensure general tidiness to avoid tripping over cords and equipment – make sure cords do not trail across the floor, and sweep up threads and small pieces of fabric that could be a slip hazard. • Do not walk around holding sharp implements.
Using equipment	• Place scissors in a visible, uncluttered space and keep pins in a container. • Cut fabrics on a flat surface, not while holding them in your hand. • Avoid hot surfaces and steam from irons.
When using the sewing machine or overlocker	• Be aware of your posture – ensure the sewing machine/overlocker is at the correct height and distance; have your chair adjusted to the correct height; keep your shoulders down and your ears back in line with your shoulders whenever possible to avoid neck strain; make sure the needle of the sewing machine is directly in front of your chest. • Avoid eye strain by having good, direct lighting, and regularly look up and focus on something in the distance. • Take regular breaks and stretch at least every 30 minutes.
Using machines	• Ensure general electrical safety, e.g. tell your teacher about frayed cords; turn off the sewing machine at the power point before adjusting or changing attachments. • Be vigilant by concentrating and not chatting while sewing to avoid sewing over fingers.

Wood, metal and plastics

The most common injuries in wood, metal and plastics workshops result from:

- incorrect use of equipment or lack of training
- not using safety guards
- machinery that is not maintained to a safe standard
- not wearing the right personal protective equipment (**PPE**)
- an unsafe working environment
- poor manual handling practices.

PPE personal protective equipment: items such as safety glasses, shields, masks and gloves, needed for protection when using a machine or equipment

9780170400336

Guidelines for wood, metal and plastics workrooms	
Safe working	• Only use equipment once you have been taught how to use it correctly. • Know the location of, and how to use, the emergency stop button on all machinery. • Report all accidents and faulty equipment to the teacher. • Keep your work area tidy and return tools to their storage area. • Use tools for their correct purpose and always carry sharp tools (such as chisels) with the point facing downwards.
Personal safety	• Understand why different PPE is used and take responsibility for wearing it when required, e.g. always wear eye protection when operating machinery, hearing protection for noisy operations and fully enclosed shoes at all times. • Read the safety data sheet (SDS) and understand all the hazards associated with the chemicals/materials you are using; follow the safety precautions on the SDS.
Machine safety	• Never use a machine without the correct training from your teacher or a qualified instructor. If you are unsure about operating procedures, check with your teacher. • There should be no more than one student operating a machine or within the safety zone at one time. • Always check that machine guards are in place. • Be aware of the hazardous parts of a machine – sharp blades, trapping or crushing points, etc. – and keep your body and clothes away from these.
Portable power tools	• Check the lead, plug and machine for damage and report any damage to your teacher; do not use a damaged portable power tool. • Make sure the machine is turned off at the power point when checking settings and fittings or changing parts, such as router bits.

General safety

Guidelines for manual handling – to avoid musculoskeletal injuries	
Lifting and moving materials	• Ask for help when lifting more than 10 kg (such as the product you have made); a two-person lift is safer. • Use suitable lifting equipment or a trolley for carrying materials whenever possible. • Learn and use the correct method for lifting.

Risk management

A risk is the 'chance of something going wrong', and risk management is a process used to recognise hazards, and assess, manage and control risks. Measures can be put in place to either remove a hazard or to lessen the harmful effects of an incident if it occurs. In business, risk management is used for financial matters, staffing, health and safety, dealings with partners or competitors, company reputation and consumer confidence. You need to apply it not only to machinery but also to materials and your finished product.

The information in the following table is adapted from 'Controlling OH&S hazards and risks: A handbook for workplaces' by WorkSafe Victoria.

Risk management has four steps	Concepts to be understood
Step 1: Identify hazards – know what hazards are present; recognise what it is about a piece of equipment or a process that might cause injury with incorrect use	**Hazard** – a dangerous thing, situation or action; something currently in, or which may in future be in, the work environment that has the potential to cause harm to people; e.g. cords across walkway, sharp spinning blades
Step 2: Assess risks – understand the nature of risks, the harm that could occur and how likely this is	**Harm** – death, injury, illness (physical or mental) or disease **Risk** – the chance (or likelihood) of something negative happening, i.e. that a hazard will cause harm to people; e.g. the cord might cause tripping and an injury; fingers could touch the blade and be badly cut
Step 3: Control hazards and risks – determine options for eliminating or reducing risk (precautions), selecting the best method and implementing it	**Control** – a thing, method or action that eliminates, prevents or reduces the risk so far as reasonably practicable; the act of doing this; e.g. never have cords across a walkway unless you tape them down; use another method to cut, or use the guard to limit chance of cuts
Step 4: Check controls – review the implemented controls to ensure they are working as planned and effective; monitor and learn from incidents	**Check** – don't assume things are under control; inspect at regular intervals; communicate with others exposed to the same risk; e.g. look for where cords are placed and fix if necessary; check guard is in correct position

Download the booklet 'Controlling OH&S hazards and risks: A handbook for workplaces' by WorkSafe Victoria. A link to the WorkSafe website can be found at http://nelsonpdtvce.nelsonnet.com.au.

Risk assessment

A risk assessment occurs before production. It is an important **occupational health and safety (OH&S)** tool used to prepare and follow safe practices in every aspect of design and construction.

occupational health and safety (OH&S) programs that ensure workplaces are safe for all who enter them

In all units of this study you are expected to undertake risk assessments that:

- refer to your 'production steps' plan
- identify all hazards and any injuries or harm that could occur in the steps (processes/activities) involved
- estimate the level of harm that could occur, ranging from minimal (requiring first aid) to serious (requiring hospitalisation) and estimate the likelihood of an incident – as high, medium or low. The combination of these two aspects gives you an assessment of risk
- outline suitable controls (precautions) to implement that are the most effective ways to remove or reduce those risks. Demonstrate that you know exactly what to do to remain safe. List the exact PPE required.

Workbook DFT: Risk assessment sheet

You should set out your risk assessment in columns, as in the chart on the following page. Use the safety information on these pages to help you. Your teacher will also tell you what is expected.

Risk assessment chart

Process or activity	Hazard	Possible harm	Likelihood/ seriousness	Risk controls
e.g. Using the router	Cord across walkway	Bruising from being tripped	Medium/Low	• Tape cord down or run above workbench
	Blade cutting through electrical cord	Electrocution	Low/Very high	
	Sharp spinning router bit	Dust and splinters in eyes, breathing dust, cuts from projectiles	Low/Medium	• Wear eyeglasses, tie long hair back, wear sturdy shoes
		Loss of fingers due to hitting the cutting blade	Low/High	• Make sure work is secure with clamps • Check router bit is set up correctly and tightly

Hints for risk control

During the design stages, reduce risks by:

- researching, selecting and using the safest machinery, tools and processes (also chemicals and materials)
- considering design features of your product that are least likely to cause injury.

During production, reduce risks by:

- taking responsibility for your safety by researching the risks, understanding them and using safe work practices, such as wearing appropriate PPE and cleaning up dust and spills
- being correctly trained in processes and the use of machinery and equipment.

Hazards, possible injuries and suggestions for risk control at different stages of product production or use

Stage of production or use		Areas of hazard – examples	Possible injuries – examples	Risk controls – examples
Pre-production – sourcing and storage of materials		• Moving materials, weight and sharp corners/edges	• Injuries to back or neck • Striking, crushing, etc.	• Manual handling training, use of trolleys and ladders, two-person lifts
Product manufacture	Preparing materials, measuring, marking, cutting	• Machinery – moving parts, blades, needles, etc. • Electrical cords and use of some electrical equipment • Dust, vapours, noise	• Striking, crushing, entanglement, cuts • Tripping, electrocution • Breathing problems, eye and hearing damage	• Correct training, use appropriate PPE • Electrical cord checks • Use the safest materials and chemicals • Good ventilation • Use machine guards
	Joining and assembling	• Toxic glues	• Lung, eye, skin and internal organ damage	• Follow SDS safe use procedures
	Finishing	• Vapours and fumes from finishes (paints, oils, etc.) • Heat and steam from iron or steam press • Dust from sanding	• Inhaling toxic chemicals – damage to lungs, eyes, skin and internal organs • Burns • Inhaling dust – damage to lungs, nose and throat	• Follow SDS safe use procedures • Use appropriate mechanical ventilation • Correct training • Use a dust extraction system and wear a particle mask

Stage of production or use	Areas of hazard – examples	Possible injuries – examples	Risk controls – examples
Transport	• Weight and size of product • Sharp edges or parts	• Manual handling injuries • Puncturing, cuts	• Dismantling or sectioning product for transport • Padded protection
Product use	• Moving parts of the product, e.g. drawers, doors, zips • Weight and size of product • Sharp edges	• Crushing or cuts • Manual handling injuries	• Designing adequate space around moving parts to reduce/eliminate jamming • Clear instructions on safe product use • Eliminate sharp edges
Product disposal	• Fumes or dust emitted as the product breaks down	• Damage to lungs of those close by	• Give clear information on appropriate disposal

Safety data sheets (SDS)

It is critical that you know about the dangers of the chemicals and materials you are using, particularly as the harmful effects of hazardous substances are often not seen for a very long time. An example of this is the many people who were exposed to asbestos dust and later developed mesothelioma, a rare and agressive cancer. Prolonged exposure to any type of dust is harmful.

Safety data sheets, or SDS (previously known as material safety data sheets, MSDS), provide information about substances and their associated hazards, and are written in reasonably straightforward language. They inform you whether a substance is classified as hazardous to health or not and what safety procedures should be followed, as well as how to dispose of the material after use.

Companies that make or distribute materials and/or chemicals are required to provide an SDS when asked. By law, all schools/workplaces must have an SDS on all of the materials/chemicals being used that are classified as hazardous. Your teacher should have SDS readily available for you to read, but you can also use a search engine to find an SDS online for most finishes and chemicals used in schools. These can be downloaded and put into your folio, and you can highlight the sections related to hazards, health effects and safety precautions.

Materials and costing list

A materials and costing list should also be developed for your preferred option. In your materials list, include all the components and extras that will be needed. If helpful, you can put in an estimated cost and then, once you buy the materials, add the actual cost.

- A materials **cutting list** is for planning and costing wood and metal projects (this is sometimes called a bill of materials); see the example below.
- A **materials and notions list** is for planning and costing fabric projects (notions are zippers, buttons, etc.).

Workbook DFT: Materials list and costing

Coffee table: materials cutting list

Part of product	Number	Length	Width	Thickness	Type of material	Cost per unit	Total cost per part
Legs	4	400 mm	45 mm	45 mm	Blackwood	$	$
Rails – short	2	450 mm	60 mm	19 mm	Blackwood	$	$
Etc.							

9780170400336

Quality measures

quality control
quality measures and quality checks to help ensure your product turns out to be the best possible quality

Quality measures and quality checks will help you to avoid mistakes and to ensure that your product turns out to be the best possible quality. They help you to have **quality control**. Preventing errors also prevents waste of time and materials.

Quality measures can be written as 'tips' to help complete processes accurately and expertly, or as a checklist. They can be added to or written up in a separate table for particular steps in your sequence plan. Think of the equipment or skills you need to achieve the best possible result in your processes. Some general quality measures are set out in the following table.

General quality measures	
When selecting material	• Look for flaws: tiny holes that might affect strength or appearance, variations in colour or even thickness, or skewed weave (fabric). • Look for warping, check that the grain suits your construction, check for knots where strength may be required (wood).
Before laying out pattern pieces or templates	• Check that the amount of material is sufficient. • Check that the material is clean. • Wash material to pre-shrink if necessary (fabric).
When laying out pattern pieces or templates	• Check that pieces are laid out accurately, along or with the grain as required for the material. • Lay pieces as close together as possible to minimise waste (all materials), but include room for saw cuts when marking out (wood, metal and plastics).
Before marking material	• Double-check all measurements and re-measure if necessary. • Check for squareness on face and edge (wood).
When marking material	• Make sure angles are accurate, especially any right angles, by using a set square (wood). • Mark lightly or use an instrument for marking that will not show up on final product (or can be easily removed) .
When cutting out pieces	• Concentrate and cut as accurately as possible using conventional guiding methods.
Before joining pieces	• Label pieces with removable marker or chalk to avoid mix-ups.

The table above identifies some general considerations for quality measures in the first production steps, which are usually the selection, measuring, marking out and cutting of material. However, you will write up your own quality measures in a more specific way that is relevant to, and important for, your particular materials and processes for all production steps. You can use textbooks or online videos related to your materials to assist you here.

It is also extremely useful to add a column explaining how you will achieve this quality and to include the tools, equipment or technique you will use to help you achieve it. One excellent way to achieve a high level of quality is to practise! Do as many trials as you need to improve your work.

After the process is finished, do a **quality check** to see if it was completed to the quality expected. Do this by looking at and inspecting your work to decide if it needs re-doing or is of a satisfactory quality.

You can add to your quality measures list throughout production as you learn better ways of doing things.

Modelling

Making miniature versions or scale models of your ideas is not only useful in the design and development stage, but can be invaluable before you start production. All aspects of your design will become more apparent in a 3D model than through a drawing alone; and you can check the dimensions and proportions, and any mechanisms and components. Modelling is also helpful if you aren't confident when drawing.

Models can be made of paper, modelling foam, fabric, cardboard, plastic, timber or clay. Once you have made a model, take a photograph to put into your folio.

Silver paper, fabric and net pinned together to judge placement for a hat design, from students in the So You Think You Can Design competition, run by DATTA Vic (left); a rose folded out of paper to check the amount of fabric needed (right) by student Riona Finn

Reminder for Unit 3: check how your production plan will be assessed. In Unit 3 you also need to identify relevant manufacturing processes needed to enable mass or low-volume production of your preferred design. *To find out more, go to page 403 in Chapter 14* and refer to the current Assessment Criteria published in the *VCAA Bulletin* in February each year.

UNIT 3

Production

In this step of the design process, you will implement risk management and follow your plans to safely and competently construct your product. You may find you need to revisit other steps in the design process from time to time. For example, many students think that evaluation happens at the end of the process, when the product is finished, but the evaluation of choices and procedures, using critical thinking, will be happening constantly. This continual evaluation may mean that you need to do more research, create some more design ideas, carry out some more trials, experiment with different materials, refine the working drawings or change some components. This is normal practice!

Product or prototype?

In all units, if appropriate, you may construct a high-quality prototype of your preferred option as the 'end-product'. Substitute materials and processes can be used to create the structure, form or finish of your design, in place of more expensive, unavailable or highly complex means. 3D printing could be used for parts that may not be possible to create using normal classroom facilities. Electronic or digital parts may be non-functioning but their placement and position can be indicated on your prototype. All 'end-products' must be full scale.

9780170400336

Documenting production

In this study, you are expected to record your progress during production with photos and text, and add this documentation to your folio. This helps others to see your progress and to understand why certain decisions were made and the context in which you made them. It identifies what was done by your own hand, by machine or by an 'expert'. It also cements your own knowledge, helps you to evaluate your progress through production and provides evidence for **authentication**.

authentication confirmation that you truly and genuinely completed the work yourself

Using a journal or log to document production

Your journal documents the steps completed in your sequence plan. It should be supported by photographs, so aim to have a digital camera (or phone, if allowed) with you at all sessions. Don't forget to check the quality of the photos, too! Upload your photos onto a computer straight away, so that they don't become 'lost'.

Make sure you record and keep:

- clear photos
- a summary of production carried out with the tools, materials and processes used
- dates for work completed and the amount of time taken
- assistance given or processes outsourced
- observations of things you have learned and experienced
- quality measures you implemented
- the safety procedures followed
- aspects that could be improved.

It is also very helpful to include a statement at the end of each session entry that tells you what you need to do in the next session. This can save time and provide the answer to the question, 'Now, where was I?' For example, you may describe your day's progress like this:

Workbook DFT: Journal template

> Today I marked and cut the front panels for my cabinet drawers. I expected it to take 90 minutes. Unfortunately, I measured incorrectly and will need to remake one of the panels, so I will need an extra 30 minutes as I have to get all the tools and templates out again.

Sample journal layout

A table such as this might be a useful tool to record your progress along with photos of your progress.

Date	Time taken	Explanation of step/s completed or outsourced	Materials and equipment used and safety procedures	Quality measures used	Modifications (with reasons)	Next session I need to …

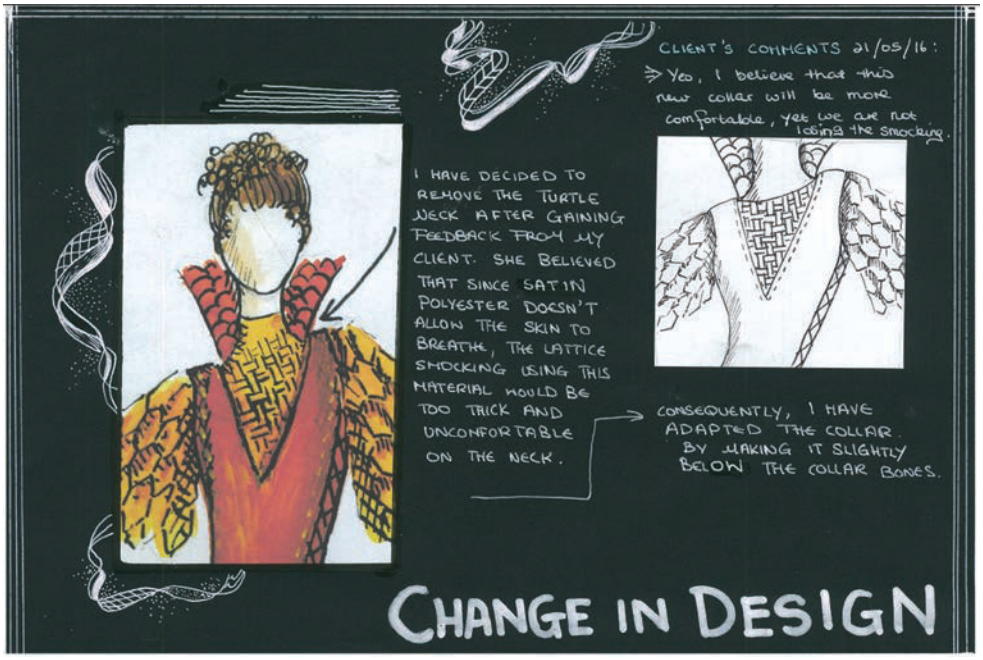
Modifications to designs or plans during production

If you make changes during production, check with an end-user to get their feedback. Modifications to the design or plans can be noted in your journal. A modification sheet is another method to keep track of any changes.

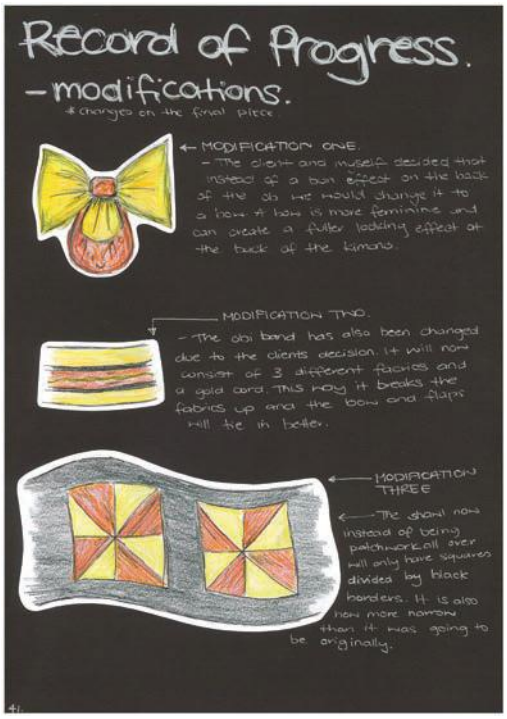
Modifications can be communicated visually:

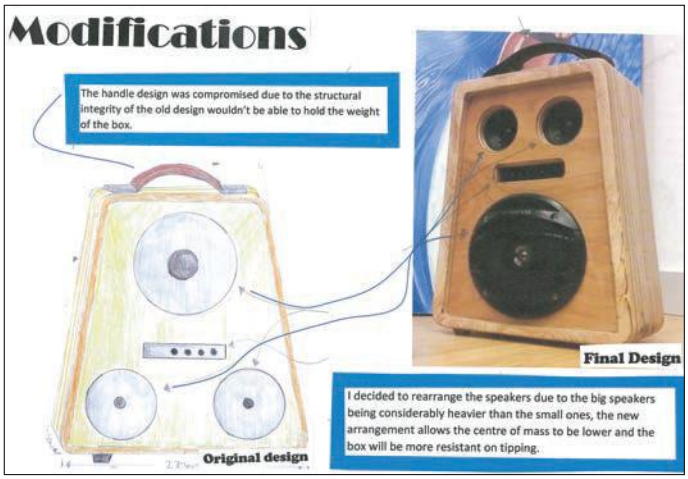
- with diagrams – this will help in exam preparation, where you are often required to draw diagrams of processes
- using a copy each of the timeline and sequence plan, with modifications scribbled onto them
- with photos of mistakes or errors and how they were fixed

- by including annotated photos as normal journal entries
- by copying relevant sections from the working drawing that have been changed, and redoing them.



Workbook DFT: Modification sheet





Journal pages, showing modifications, by students Lian Wilson (top), Caitlin Hogg (bottom left) and Jarrod Murphy (bottom right)

Reminder for Unit 3: check how your product plus your record of progress, including modifications, will be assessed. Refer to the current Assessment Criteria published in the *VCAA Bulletin* in February each year.

4 EVALUATION

Evaluation is the fourth and last stage. Evaluation is an important part of any stage of the design process, but is particularly important at the end. In industry it is extremely important, as it allows the designer or manufacturer to see how the design could be improved, how things could have been done faster, with fewer errors, in a better way and perhaps using different methods and materials. It creates the way for improvement in the next version of the product or future products.

In this study your evaluation takes the form of a written report. This is the stage where the evaluation criteria you wrote in the first stage will assist you. *To revise evaluation criteria, go to page 19.*

Evaluating the finished product (or prototype)

To see how well your product has solved the design problem, achieved its overall purpose and met the identified need, it needs to be checked, trialled and/or tested. You have already suggested methods for doing this with each of your evaluation criteria questions earlier in the design process (as the fourth part). Now is the time to put these methods into practice.

When writing your report, you need to change the wording from the future (i.e. I will ...) to reflect the past, i.e. how you tested it. *Refer to the examples of checking methods in the four-part criteria on pages 20–1 to ensure you have a variety of methods.*

Perform all these checks and make a comment on how each criterion has been fulfilled.

UNITS 3&4

In Units 3 and 4, you also need to obtain feedback from the end-user/s.

In Unit 1, your evaluation report must include the significant differences between the original product and your redeveloped product. Be sure to mention the similarities, as well as explaining the differences and their success or lack of success. You must also include how you have improved the product's sustainability, or explain how this would be improved in mass production. *To find out more about evaluation in Unit 1, see page 263.*

UNITS 1&2

In Unit 2, your evaluation report must cover the team effort as well as your own effort. It must also refer to each of the following:

- the historical/cultural design movement or style researched and any influence this had on the product/s
- user-centred design factors and how these were researched and incorporated into the product/s
- sustainability factors and how these impacted on your choices.

To find out more about evaluation in Unit 2, see page 284.

The following example is suitable for demonstrating how you checked each criterion:

Evaluation of final product: storage unit	
Evaluation criterion 1: Does the storage unit allow for easy assembly and disassembly?	
Checking method	To check this, I asked Chris (the end-user) to disassemble and reassemble the unit and I timed him.
End-user comment/ feedback	It took Chris 40 minutes. He struggled with getting the shelves back in the right place, but he said, 'Now that I've done it once, I feel very confident that this will be an easy thing for me to do.'
My response	Although Chris was daunted at first, the disassembling and reassembling is very straightforward and fairly fast. I'm proud of it.
Suggestion for improvement	I think it might help to put instructions for disassembling/reassembling under the bottom shelf ... or perhaps online.

9780170400336

When it comes to suggestions for improvement (required for all units), there will be some overlap, so there is no need to be repetitive! Instead of making suggestions for each criterion as above, you could group them as in the example below.

Suggested areas for improvement

Aesthetics	Functional aspects	Suitability of materials
• How could the visual, tactile and aesthetic factors of the product be improved? Look at your use of line, colour, texture, proportions, balance, symmetry, etc.	• Could the safety, ergonomics, performance and/or sizing be improved? • Do the secondary functions support the primary function effectively? • Is it easy to operate?	• Are the materials flexible or rigid, strong or light, as needed? • Does the combination of materials work well? • Are the sustainable materials suitable?

Quality	Time and budget
• Could it have been made to be more durable/reliable? • Are the joins strong with no errors? • Does it have ease of maintenance and repair? • How could the quality be improved? • Did the quality measures help enough? • Could skill trials and practice have assisted?	• Did I finish on time? • How could my time have been managed better? • Could better planning have improved the amount of wasted time or costs?

In Unit 3 you need to create user instructions or care labels for your product; *to find out more, go to pages 413–14*. Reminder for Unit 3: refer to the current Assessment Criteria (published annually in the *VCAA Bulletin*) to check how your evaluation report and user instructions or care label will be assessed.

UNIT 3

The design folio

Your design folio needs to communicate your progress through the design process, so here are some tips to aid you in your communication.

The main qualities of an effective folio are:

- clarity – of text and images
- content – depth and relevance
- impact and creativity.

Clarity

Clarity involves making sure that all of the components of your folio are clear and well organised. For example:

- Use large headings that clearly indicate the content and the purpose of the page.
- Use an easy-to-read (large and clear) font or text type that leads the reader to the important content quickly. Any annotations on drawings also need to be easy to read. Use arrows, as they help to lead the eye.
- Use the same font for major headings and the same (or another uniform) font for written information.
- Use visual methods to display information wherever possible. Data Viz UK has collected ideas on how to represent data visually and the benefits of this. A link to this website is at http://nelsonpdtvce.nelsonnet.com.au.

9780170400336

- Drawings need to be large and clear. Pages of sketches may have small images as you work out your ideas, but each design option should cover most of a page.
- Adjust tables to display the content clearly and where possible on the one page, i.e. narrow columns to suit.

Content

Consider placing the content in sections that reflect the design process. If you have jumped backwards and forwards in the design process, place the material where it occurred in your design process and label it clearly.

Make sure that the written information and drawings show that you have thought deeply about the design situation. You need to argue the pros and cons of ideas presented, and discuss them fully (i.e. not just say, 'This design is cool').

Check that all your comments and writing are relevant and that they refer to or expand the design brief. Don't waffle about inconsequential things. The people viewing your folio usually have only limited time; they want to see that you can sort out and convey important information (things that come from the design situation, and/or that may affect your design choices) and not get lost in irrelevant detail.

Impact and creativity

Having impact means that a folio (as a whole, and parts within it) is powerful and grabs the viewer's attention. The following things give a folio impact:

- powerful use of colour, line and shape in folio presentation
- strong, clear drawings – using techniques such as rendering, clear drawing lines, dark or coloured backgrounds and accurate perspective (where appropriate) to help make drawings jump off the page
- adequate space around ideas, i.e. not cluttering pages too much but neither having too much empty space.

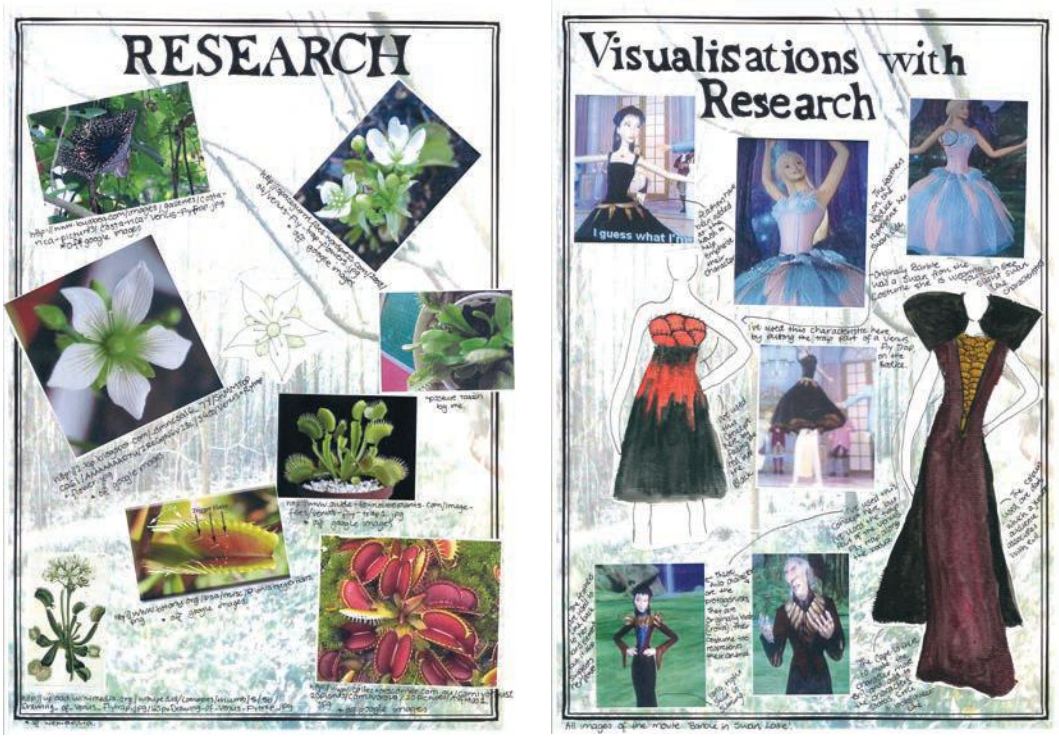
Extracts from the folio of student Rachel Krause, showing natural objects that inspired her designs, along with client feedback and colour suggestions

Creativity in your folio is shown by:

- experimentation (with designs, materials, ideas and presentation) – being able to visualise and express new ideas and solutions
- thinking laterally – not coming up with predictable solutions, and having the ability to surprise the viewer

- showing flair in the use of colour, shape, line, drawing techniques, etc. and combining unexpected or unusual elements
- having both a practical and an aesthetic eye, and making good decisions about what will work and what won't.

Creativity can be shown through your approach to both the aesthetic and the functional aspects of your design options. Critical thinking is demonstrated by narrowing down the contents in your folio to what is relevant and achievable.



Research and visualisation pages for a Venus fly trap costume by student Sarah Luisi

iStockphoto.com/petrenkod

CHAPTER 3 Design and development

CHAPTER FOCUS

In this chapter you will learn about:

- Design thinking – methods for being creative and critical p. 52
- Use of mood boards p. 56
- Types of drawings p. 59
- Drawing and design:
  - Wood, metal and plastics p. 59
  - Fabrics, fibres and yarns p. 68
- Design aesthetics: the design elements and principles p. 74
- Using design elements and principles:
  - Wood, metal and plastics p. 81
  - Fashion – including style p. 84

Annotations are an important tool to articulate and communicate design thinking.

DESIGN THINKING

Design thinking occurs most intensely in the design and development stage but is involved throughout the product design process. It is about researching widely and thinking creatively to generate multiple ideas, combined with thinking critically to make decisions. It involves consideration of important factors such as the end-user, the most suitable materials, aesthetics, construction methods and sustainability. It is thinking that brings the best ideas to fruition.

Creative thinking is assisted by **divergent thinking**; allowing one's thoughts to go wide. It comes from open-mindedness, flexibility and a curious approach. It includes exploring and investigating.

Critical thinking is done in conjunction with **convergent thinking**; bringing one's thoughts into focus. It includes questioning, clarifying, planning, analysing, examining and testing information and ideas. Both types of thinking are assisted by research.

divergent thinking considering a wide variety of ways in which a problem may be solved

convergent thinking bringing the most suitable ideas together

9780170400336

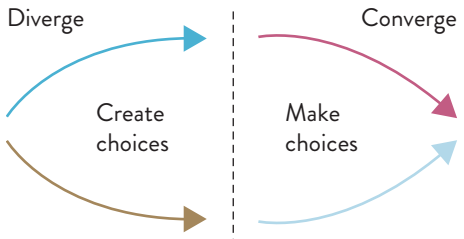
Divergent and convergent thinking

Divergent thinking is used to consider a wide variety of ways in which a problem may be solved. 'Divergent' means moving in different directions. It refers to presenting ideas that are seemingly unrelated. It is similar to lateral thinking. *See page 54.*

Divergent thinking is conceptual and problem-focused. It says, 'This is the situation or problem we are starting out with. What are all the possibilities?'

Convergent thinking involves bringing the most suitable ideas together. 'Convergent' means coming together from different directions. It refers to the narrowing down of possible ideas to probable ones.

Convergent thinking is analytical and solution-focused: 'This is where we need to get to. How do we get there?' In the design process, proposals (ideas) are critically evaluated against the requirements in the design brief.



Divergent and convergent thinking

Creative and critical thinking

Creative and critical thinking are sometimes portrayed as opposing things – right and left brain thinking, freewheeling and rigid, or 'artistic' and 'scientific'. However, in the design process, it is important that both forms of thinking are used together to create quality solutions. When looking at the techniques in the table on page 55, think about how they can be applied simultaneously to support each other. You may have a natural affinity to a particular way of thinking through a problem; but applying a wider range of approaches will assist you in developing ideas and solutions with greater depth and breadth.

Being creative and innovative

Creativity and innovation are probably the most difficult design concepts to define. The terms are often interlinked and can sometimes be interchangeable. The terms are also so overused in such a wide range of circumstances that it is difficult to know what they actually mean. Generally we think that:

- **Creativity** is creating something through an unusual or unexpected combination – of lines, textures, shapes and colours; of materials and their accepted uses etc. It is generally linked with the aesthetic or visual aspects of an object or concept, but it is not confined to only that aspect. It can also relate to functional aspects and practical problem-solving.
- **Innovation** is about being inventive, taking a completely different approach to an existing product or situation, or applying concepts from one area to another. It is about creating something in a previously unthought-of way. It is often linked to the more functional aspects of design and is usually considered an improvement.

There are many areas in which these two concepts overlap. It is often said that it takes creativity for an innovation to occur. In this book, the term 'creative' or 'creativity' will be used, but the points that follow apply to both concepts.

creativity approaching or exploring something in new or unexpected ways to create something unique

innovation pulling existing ideas, knowledge or concepts together in a new and different way that is considered an improvement

Creative thinking

It is helpful to think of creativity as something like a muscle that gets stronger and more agile the more it is used, and dwindles if it isn't exercised. It is sometimes difficult to start connecting the creative areas of your mind. But by developing some strategies and skills, and giving it a go, you will become more confident in your ability to think creatively. As mentioned

9780170400336

earlier, this is closely aligned with divergent thinking. Techniques for creative thinking are listed in the table on the next page.

Two quotes from Albert Einstein:

> 'Problems cannot be solved by thinking within the framework in which the problems were created.'

> 'If at first, the idea is not absurd, there is no hope for it.'

PROFILE: EDWARD DE BONO

lateral thinking 'sideways' thinking – being creative through an indirect approach, not an obvious one; using new approaches to solve a problem

The Maltese-born psychologist and writer Edward de Bono has spent years researching and writing about how to use the brain creatively. He was the originator of **lateral thinking** – a term that is now used worldwide and in a huge range of situations. He developed activities and exercises that help people to understand how their minds function, to recognise their strengths and weaknesses, and to work on ways to increase their ability to think laterally, escape habitual mind patterns and open the mind to new connections. He also identified six modes of thinking and labelled them as coloured hats. To be effective, different 'hats' need to be used to address a problem.

- blue for **managing** – an overall look at what is required
- white for **information** – getting together the available information and facts
- red for **emotions** – reactions or statements without reasons
- black for **discernment** – choosing, being logical, practical and realistic
- yellow for **optimistic response** – looking for positive reasons in ideas
- green for **creativity** – following random thoughts.

Search out information about de Bono's work and try out some of his activities, such as thinking of a solution to a simple design problem by using three completely unrelated everyday objects or applying all the 'hats' to devise solutions.

Critical thinking

Critical thinking involves deciding on what is practical and achievable within your existing workshop, the skills you have (or can learn) and the time available. Rational thought and clear judgement are applied to each idea to see how it suits the design situation and the needs of the user. It requires asking the right questions, looking at your designs to see if they are too complex or too simple; looking at all the information you have researched, checking facts and then analysing, combining and applying it to create a rational, well-judged and suitable solution.

As mentioned earlier, this is closely aligned with convergent thinking. Techniques for critical thinking are listed in the table on the next page.

For more information on critical thinking, go to the Critical Thinking Community website and click on 'Begin here', and then on 'Learn the elements and standards'. There is a link to this website at http://nelsonpdtvce.nelsonnet.com.au.

9780170400336

Creative and critical thinking techniques

Creative thinking techniques	Critical thinking techniques
Brainstorming – useful in a group, many ideas are put forward and all considered, keeping all ideas until the process is over **Mind mapping** – representing and organising ideas visually **Brain writing** – ideas are written down, passed around and extended on **Thinking laterally** and 'outside the square' (see 'Profile: Edward de Bono') **Applying** things from one area to another unrelated area **Looking, listening and feeling** what is around you **Observing and adapting** existing ideas or products and nature **Escape thinking** – a method to challenge conventional thinking **Being curious** about how things work, what makes people tick, learning about things **Synectic** thinking (see below) Using **SCAMPER** triggers (see next page) **Exploring** the design elements and principles (see more later in this chapter) **Collecting** objects and materials of interest **Experimenting** with materials, processes and ideas **Expressing/communicating/recording** ideas and **annotating** them	**Questioning** – asking really targeted questions (How can I do this? How does this idea meet the requirements of the end-user?) **Critiquing** – looking at the positives and negatives **Researching** – seeking, sorting and using information; filtering what is important from what is not **Testing and measuring** – observing, using objective measuring tools and standards **Analysing** products and behaviour for ideas, problems and successes **Comparing /contrasting** ideas and synthesising the best **Using logic and reason** – thinking clearly; being analytical: breaking things down and examining the parts **Seeking** another point of view and noting it down **Using evaluation criteria** to select the most suitable ideas **Noting your assumptions** and habitual thoughts and why they exist **Checking facts** – using evidence to support your reasoning **Being precise** and specific, not vague **Making judgements and decisions** on what will have the most effect, and putting effort into those things **Deciding on** the best materials, colours, methods and solutions **Using worksheets** such as PMI (Plus, Minus, Interesting) and other graphic organisers (visual methods) for analysis

Workbook DFT: Mind map

'Creativity demands flexibility and imaginativeness but also tightly organised thought processes, matched by a high degree of emotional and psychological freedom.'
Taher A. Razik

Using triggers to be creative

Synectic thinking

Synectics is an ordered way of approaching creativity and problem-solving. One method is to twist things around so that what is familiar, typical or ordinary becomes strange, and what is strange, weird or unexpected is looked on as normal. William Gordon, who co-developed this method in the 1950s, expressed his central principle as: 'Trust things that are alien, and alienate things that are trusted.' He said that emotional input into creativity was more important than the intellectual component.

When designing, it can be useful to use '**triggers**' to open up new ways of perceiving things. You can take a new or existing idea and bounce it around to come up with something original. The list below is part of a **synectic** approach to creative thinking. Use one or many of these, or come up with your own ways of transforming an idea.

- Repeat – use the idea or parts of it more than once.
- Transfer – take the idea and put it into a new context.
- Animate – give the idea or an aspect of it movement or life.
- Empathise – take on the feelings of something to overlay an emotional aspect of the idea.
- Fragment – break the idea up into little pieces.
- Isolate – focus on one aspect of the idea.
- Distort – take one aspect of the idea and change it, e.g. make it bigger, longer or smaller.

triggers
words or objects that spark an idea

synectic thinking
from the Greek meaning 'bringing different things into a unified connection', synectics focuses on taking things apart and putting them together differently to transform ideas

9780170400336

- Disguise – hide or camouflage certain aspects of the idea with something else.
- Contradict – go in the opposite direction to the way you were thinking.
- Parody or add humour – make fun of the idea or an aspect of it.
- Imagine – relate the idea to dreams and the imagination.

If you want to find out more about how to use these processes, type 'synectic thinking' or 'synectic triggers' into a search engine.

SCAMPER

Developed by Alex Osborn in 1953, the **SCAMPER** list of triggers might also be useful:

- **S**ubstitute – components, materials, people, situations.
- **C**ombine – mix, combine with other components, functions or services, integrate.
- **A**dapt – alter, change function, use part of another element.
- **M**odify, **M**agnify or **M**inify – increase or reduce in scale, change shape, modify attributes (e.g. colour).
- **P**ut to another use – think about how features and functions can be used in another way, or to do something different.
- **E**liminate – remove elements, simplify, reduce to core functionality.
- **R**earrange or **R**everse – change the order, interchange components, change the speed or pattern, or turn inside out or upside down.

'It is easier to tone down a wild idea than to think up a new one.' – Alex Osborn

There are many other techniques that can be used to process and transform ideas creatively. Often they have some crossover, but it is worth checking them out as you might pick up new or different ways of working.

Using mood boards

mood board a collage of images, design fragments, textures, components, colours, words and phrases, etc., to provide a reference for visual consistency in designs, or for use as a stimulus for design ideas

Mood boards communicate a 'mood' or 'emotion' in a visual way; by showing the relevant colour, texture, shape, patterns, style and related products or components. They are fun to create, and often stimulate and provide direction for lots of design ideas. They can be crowded with information – clarity of information isn't as important as overwhelming the senses with colour, shape and movement.

Designers use mood boards:

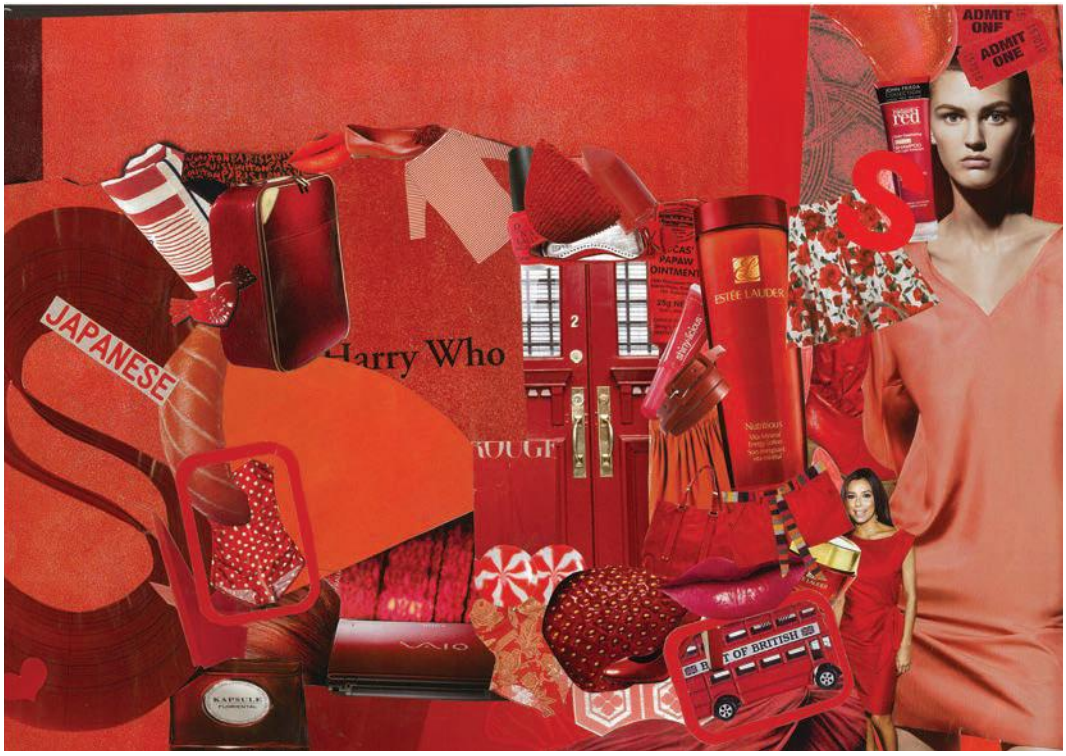
- as a reference point to stimulate ideas related to the set theme
- to communicate the designer's stylistic direction
- to 'collect' the design preferences of a client
- to set the scene for a theme (colours, textures, patterns, components etc.) to be used in a range
- in presentations to clients, to explain design choices.

Mood boards are especially helpful ahead of creating your design options. They can assist you as a reference for staying close to a suitable style or theme for your end-user. Whatever you use a mood board for, it's a good idea to add a heading to communicate its purpose with the viewer.

Mood boards can be made up of bits and pieces from lots of different sources, including:

- cuttings and images
- colour and texture swatches of fabric, plastic, metal, etc.
- unusual papers – textured, wrapping paper, etc.
- bits and pieces from existing products
- flat natural objects – feathers, leaves, bark, etc.
- words, phrases or 'slogans' that indicate the needs, desires and aspirations of the users or client.

9780170400336



Mood board by student Caitlin Hogg to capture an oriental feel and as a theme choice to a client

Mood boards can be created digitally; one thing to watch out for, however, is that software colours are sometimes hard to match in actual materials.

To create a mood board:

- Collect a wide range of materials, images and samples that relate to the theme.
- Play around with the composition of these elements on a large backing card (A3 or A2): overlap things, trim and crop images, change their angles, build up layers of colours and textures, etc.
- Attach all the elements to the backing board.
- It can be very helpful to add words and comments that explain the relevance of the image, and how the design features will help you in your designing.

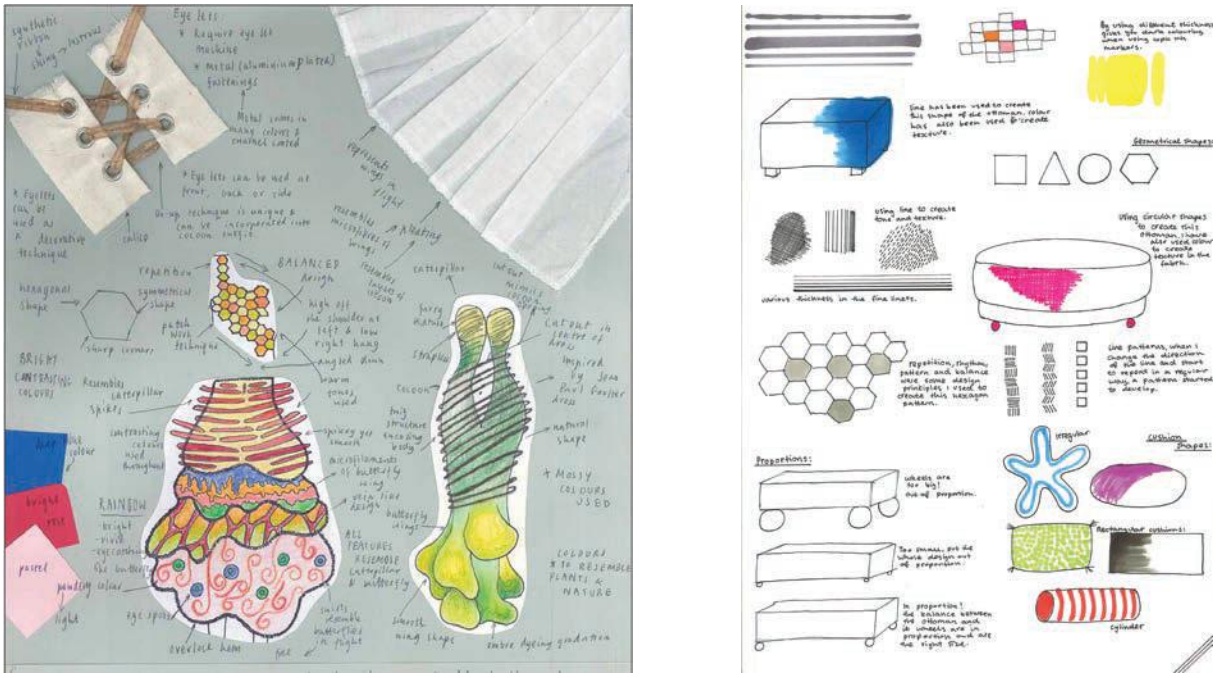
Mood boards can also be used as a springboard for design exploration and idea sketches (visualisations).

A second mood board by student Caitlin Hogg as a theme choice to a client

Student drawings

Folio drawings by Mariah Kehaidis, displayed at Melbourne Museum in the exhibition Top Designs 2017 (part of the VCAA's VCE Season of Excellence 2017) and featured on pp. 34–5 of the exhibition catalogue Top Designs 2017 (VCE Product Design and Technology, © VCAA 2017).

Folio pages by Leya Mackus (left) and Mariah Kehaidis (right), showing visualisation drawings influenced by research



Folio drawings by Mariah Kehaidis, displayed at Melbourne Museum in the exhibition Top Designs 2017 (part of the VCAA's VCE Season of Excellence 2017) and featured on pp. 34–5 of the exhibition catalogue Top Designs 2017 (VCE Product Design and Technology, © VCAA 2017).

Exploring the design elements and principles for a garment by Mariah Kehaidis (left) and for an ottoman by Sophie Allen (right)

9780170400336

DRAWING AND DESIGN

Types of drawings

Design elements and principles are parameters of the visual, tactile and aesthetics product design factor.

VCE Product Design and Technology makes a distinction between the drawings required for visualisations, design options and working drawings. The differences are explained below and throughout this chapter.

Visualisations are the first step in the design and development stage, where you play around with and explore potential ideas for the whole and/or parts of a solution to meet the brief. Graphic organisers, mock-ups and 3D models can be used in this step but mostly you will use **visualisation drawings**, which are quick sketches, called thumbnails, concept or idea sketches. These drawings can be rough or refined; detailed or simple. Both the sketches and any models are a record of your design thinking in this early stage and show the influence of your research (which you should place nearby on the same page) and annotations.

visualisation drawings sketches for getting your ideas down quickly; for visualising what is in your head

Your folio should demonstrate links between your research, visualisations and your design options along with exploration of the visual, tactile and aesthetic parameters. *See Chapter 4*.

Presentation drawings are the type of drawings expected for the design options. They are 3D, show more detail and indicate what the whole product will look like. They are rendered and coloured to represent form and textures. Annotations indicate the proposed materials and construction processes; explain how the product will suit the end-user and address the brief; and explain aspects that can't easily be seen in the drawing. Presentation drawings are expected for the design option question of your VCE Product Design and Technology exam.

presentation drawings detailed 3D drawings that show the whole product, are coloured and rendered and are used to convey a fully worked out design solution

Working drawings are needed once the design is finalised – i.e. the preferred option has been chosen. Working drawings (or technical drawings) are used to show exact measurements, shapes, joins and placement of components for construction or manufacture.

working drawings mostly 2D drawings that communicate the product specifications and components

To see which drawings are suitable as visualisations, design options and working drawings, go to the tables on pages 60 and 68.

WOOD, METAL AND PLASTICS

Visualisations

When creating visualisations it is important to start thinking laterally. Drawings can be done in pencil but the use of different drawing media, such as bold pen and 'splashes' of colour, adds visual interest. To be truly innovative, try some of the following ideas.

Research images from nature or completely different objects to inspire you. Think about using different materials, or changing a common shape. Focus on the whole product or a particular part or section, or on a functional/visual aspect. Visualise how different people might use one of your design ideas. Think of different scenarios that it could be used in. How could you make it simpler? How could you make it more entertaining or fun? How would a tradesperson use it? How would a blind or deaf person use it? Use some of the creative techniques and triggers outlined on page 55 to explore ideas in new ways.

3D models and mock-ups are also useful visualisation methods to check ideas or if you don't feel confident with drawing. Be sure to photograph and annotate them for your folio.

9780170400336

Suitable forms of drawing for wood, metal and plastics products

Drawing technique	Purpose	Visualisations	Design options (presentation drawings)	Working drawings
Concept sketches; mock-ups and 3D modelling	To express ideas quickly for parts or the whole of a product, either as drawings on paper or in 3D form			
Oblique: cabinet and cavalier	A semi-realistic, pictorial 3D view of an object with accurate measurements (front flat and sides, 45° axis)			
Isometric	A semi-realistic, pictorial 3D view of an object drawn to scale (30° axis)			To enhance communi-cation of 2D drawings
Perspective	A realistic 3D view of the object, using one, two or three vanishing points			
Orthogonal	Aligned, flat 2D views of at least three sides of the object (to scale)			

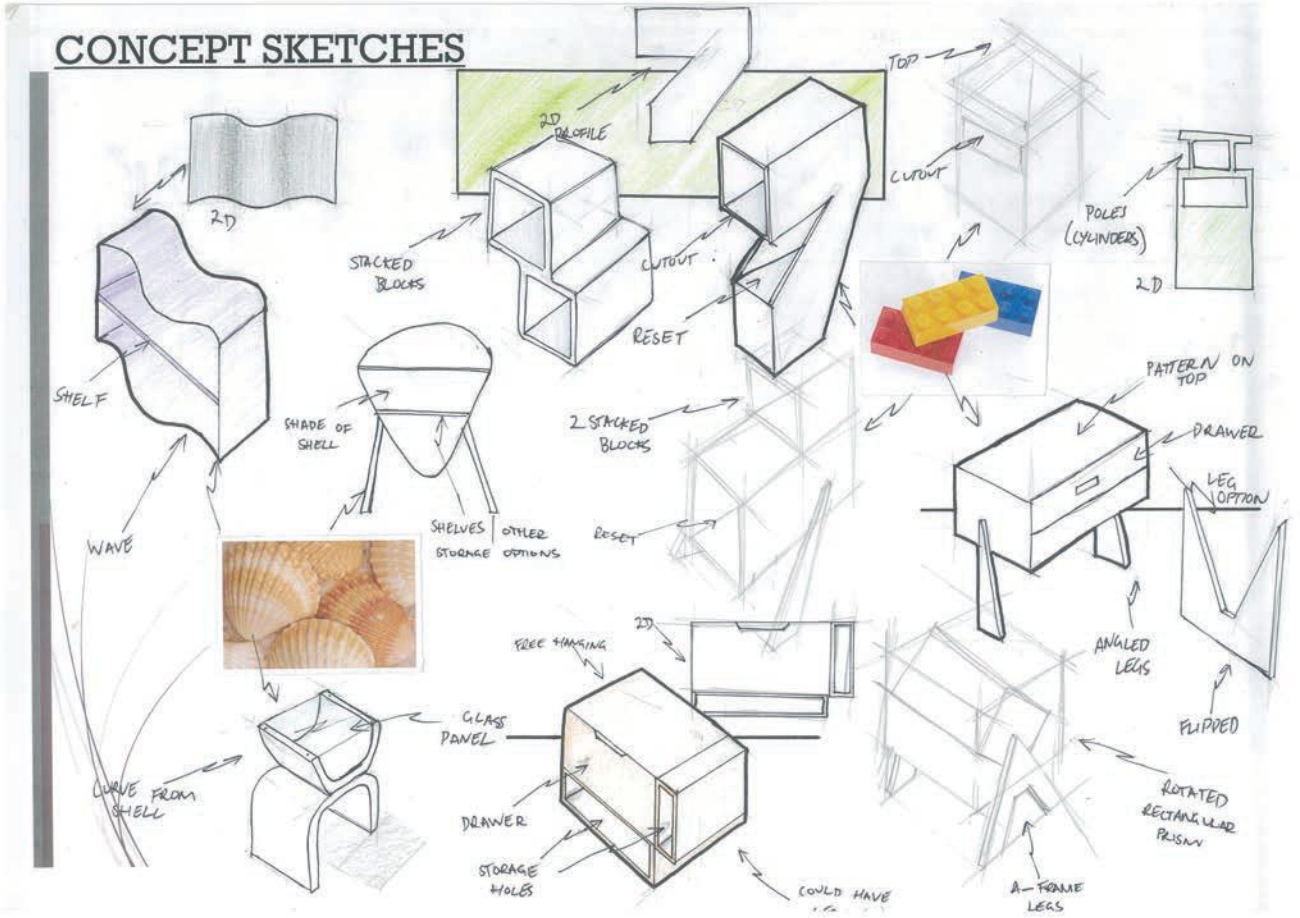
Suitable media

Using mixed media can enhance your drawings substantially. Instead of just using lead pencil, use pen to create bold outlines and add colour with washes, textas/markers, coloured pencils, textured rubbings, cloth or paper.

Here are some suggested ways to help you get started with sketching objects and design ideas:

- Start with two or three basic shapes or forms, i.e. circles or spheres, triangles or pyramids, rectangles or blocks.
- Draw lots of quick images – not too large. Play around with the placement, composition, comparative size and order, proportion, and linking elements.
- Turn some of the better images into 3D sketches.
- Refine some of the shapes and edges and add some detail.
- Avoid 'stick-figure' representations of objects; add double lines to create the illusion of the material's width.
- Darken some of the lines and add some rendering for depth.
  To find out more about rendering, go to page 63.
- Highlight the most effective sketches with a black marker background or outline; or with a coloured wash background to add impact.
- Annotate your drawings to explain your ideas and to analyse what does and doesn't 'work' for the design situation.

9780170400336



Visualisation drawings for a storage item, inspired by a shell and Lego® blocks, by student Josh Goudge

It sometimes helps to use **crating** to give a 3D representation of your idea. After drawing a flat front view, lightly draw a series of lines from the corners of your front view – all pointing in the same direction and of the same length. Then join them with lines that are parallel to the edge of the front view.

crating
drawing a 3D 'cage' to assist in creating a 3D image

Presentation drawings

Oblique drawing

Oblique drawing, or oblique projection, consists of one view drawn straight on (a flat front view).

In **Cavalier oblique** all measurements are drawn to the same proportional length, but this tends to make objects look distorted and out of proportion. Surface details are drawn to the same rules.

Cabinet oblique results in a more natural-looking drawing, but care needs to be taken in applying the half-size scale. Features on the top and sides of the object are squashed, making them more difficult to draw, e.g. circles shown on the front face appear as circles, while those on other faces are shown as ellipses. Placement of the object can be critical. Always position it so that the longest and most complex view is drawn as the front flat view.

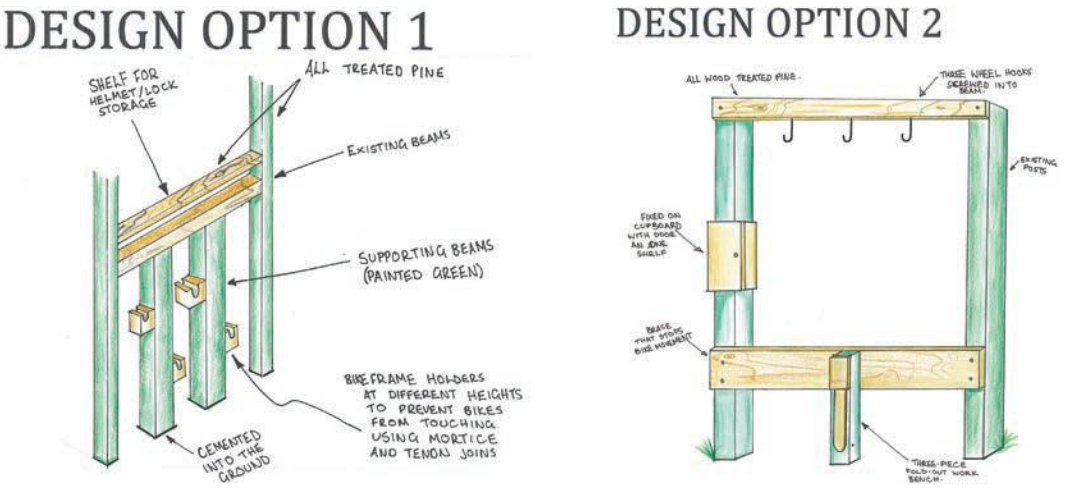
Cabinet oblique is often used to quickly assess the appearance of an object.

oblique drawing
one view of the object faces the viewer squarely (straight on) and the edges recede to one side at 45°

cavalier oblique
both the front face and the receding edges are drawn to their true or scaled size and shape

cabinet oblique
the front face is drawn to its true size and shape, but the receding edges are drawn to half their true (or scaled) length

9780170400336



Two design options by student Sam Jeffrey for a bicycle stand – at left, an isometric drawing, and at right, a one-point perspective drawing

Isometric drawing

isometric drawing
both front and side views project back from the picture plane at a 30° angle

Isometric drawing is a frequently used form of pictorial drawing. It is easy to scale and construct, while giving a semi-realistic appearance to the finished object.

Isometric drawing is based on a grid with vertical lines, and lines rising to the left and right at 30° from the horizontal (drawing tools such as a T-square and 30°/60° set square can also be used). All drawing is then carried out with reference to these lines. Because all square shapes appear as parallelograms in isometric drawings, all circles appear as ellipses. The object gives the appearance of being tilted forward towards the viewer.

Perspective drawing

perspective drawing
a drawing that uses converging lines to create the illusion of distance

vanishing point (VP)
the point(s) where lines converge, usually on the horizon

horizon line (HL)
a horizontal line drawn at eye level

Perspective drawing is used to give a realistic view of the completed article. Depending on the style you choose the object may have one, two or three **vanishing points (VPs)**.

One point or single point perspective drawing is the easiest method to use. The front view is drawn flat and the receding lines meet at a single VP on the **horizon line (HL)**, or line of sight. The positions of the vanishing point and horizon line affect how you view the object. If your horizon line is low on the page, it appears as though you are looking up at the object, and if it is high, it appears as though you are looking down on it.

One point is particularly useful when illustrating groups of objects that can be lined up with one VP, or for creating an enclosed environment (e.g. a drawing of a furnished room).

Two point perspective drawing is a perspective method that is easily adapted to projects of different sizes. Because the object 'vanishes' in two different directions, it conveys the feeling of distance and size very effectively. Two point perspective is equally effective in presenting a single object, and small articles, such as an integrated circuit or a piece of jewellery.

In two point perspective, the VPs are located to the right and left of the observer on the HL. Vertical heights are always shown at 90° to the horizontal, and the object recedes in both directions to the VPs. As with one point perspective, the positioning of the object and its VPs is important. In general, the VPs should be kept as far apart as possible, as VPs that are close together exaggerate the perspective. For ease of drawing, the top of the object should not be too close to the eye-line.

Rendering

Rendering is a collection of techniques used to make drawings more realistic by the careful application of shading, patterning and colour. For example:

- Tone shading is used to represent the areas of light and dark on an object if you imagine it being illuminated by a light source coming from a specific direction.
- Hatching uses a series of parallel lines to create the illusion of light and shadow by varying the distance between them.
- Texture shading is achieved by creating lines or patterns that represent the surfaces of various materials, such as wood, metal, brick or glass. As with hatching, lines and patterns that are close together create a darker tone.
- Colour is perhaps the most effective way to enhance your drawings. There are many techniques for colour application, and just as many media.

Markers, chalks, poster paints and watercolours are commonly used to add extra impact to pictorial drawings.

Designers often use special felt-tipped markers that have subtle differences in their range of shades. They are quick and easy to use and, with a little experience, can be used to produce some dramatic effects.

For your design options, use any of the drawing types explained on the previous pages under the heading 'Presentation drawings'. They can be drawn by hand or with CAD but remember to render, colour and annotate them. Read how you can use the design elements and principles to assist in creating aesthetic, creative and interesting designs later in this chapter.

rendering
techniques that give form by adding line, colour, texture and/or tone

An example of the use of tone shading

Working drawings for resistant materials

The most suitable working drawing for resistant materials (wood, metal and plastics) is a 2D orthogonal drawing showing several views. 3D drawings, as explained in previous pages, can be added to aid communication. However, any 'technical drawing' must be drawn accurately and to scale. They can be done in CAD. If you are drawing by hand, all lines must be precise, and straight lines must be drawn with a ruler.

You can find many examples and tutorials online to help with technical drawing.

Orthogonal drawing

In **orthogonal drawings**, each view appears as a flat 2D shape that can be used to display construction detail and all relevant sizes. Orthogonal drawings must be clear, accurate and detailed.

Third angle orthogonal projection is the accepted layout used in Australia. The rules that govern its method of presentation and the conventions used are set out by Standards Australia in AS 1100: Technical Drawing, but an abridged version is available in a handbook titled *Technical Drawing for Students*. These rules ensure that line work, dimensions, lettering, parts lists and sectioning, etc. are completed to established standards so that communication of important details is clear.

In an orthogonal drawing, views of the front and ends or sides of the object are called **elevations**, while the view from above it is referred to as the **plan**.

orthogonal drawing
2D representation of different faces of the object viewed straight on and drawn in alignment to each other, according to 'rules' or conventions

third angle orthogonal projection
a 2D drawing in which the top or plan view is drawn above the front view, the right-side view is drawn to the right of the front view and all edges are aligned accordingly

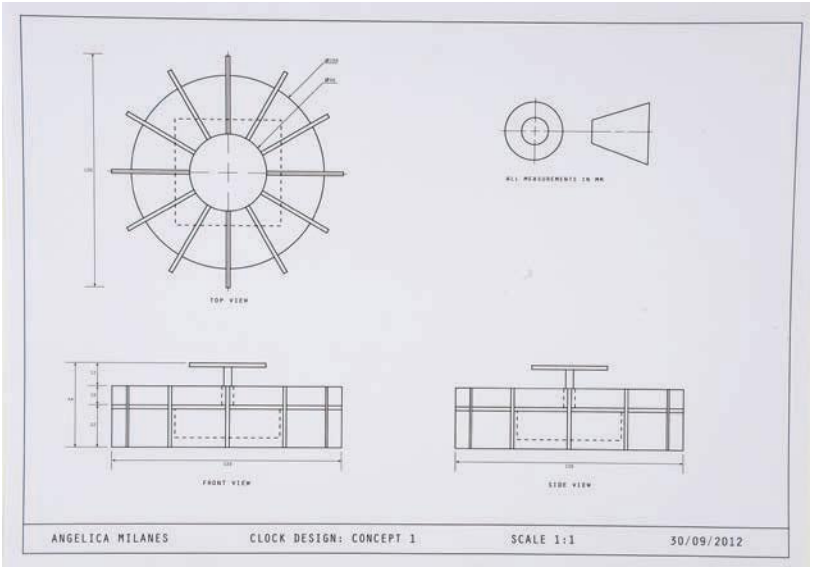
elevation
a view of a vertical face such as the front or ends of an object

plan
a 2D view from above an object

9780170400336

Positioning the views is very important in orthogonal drawing. The plan view, end view and front elevation must be aligned with each other. In third angle projection, the front elevation is drawn first, the plan view is aligned directly above it, and an end or side view is aligned directly to the right. If the ends of the object differ in shape and form, then the other end is drawn aligned to the left. The spacing between all views must be the same.

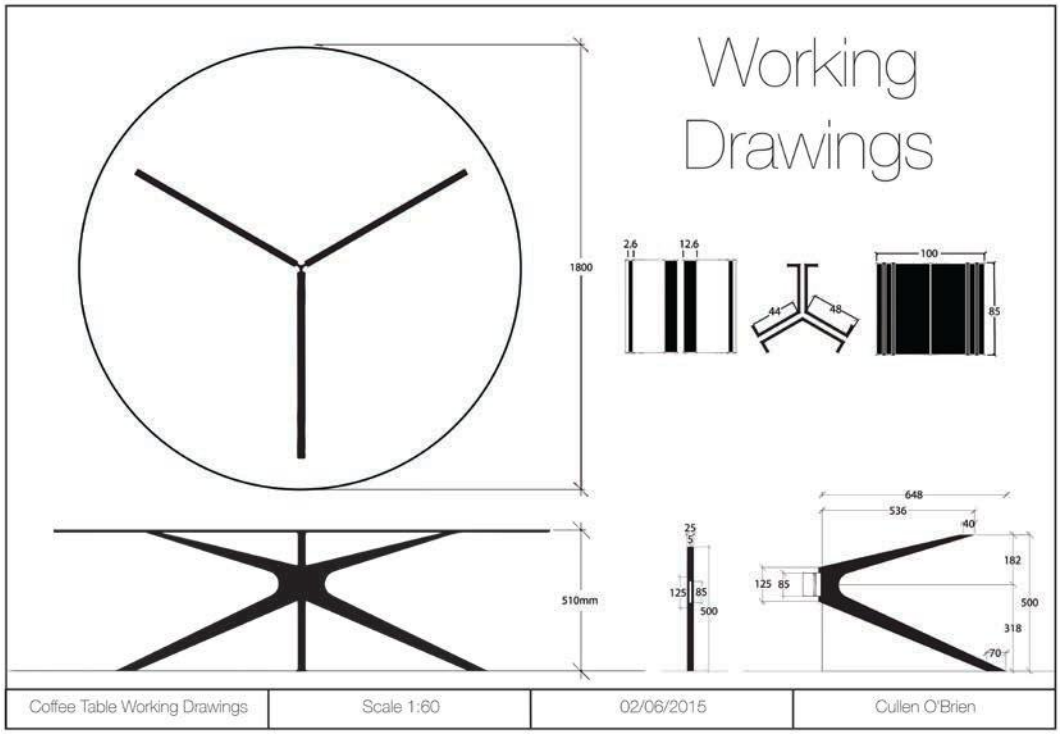
Orthogonal drawings should be dimensioned and have a title block according to the 'rules' set out in the handbook.



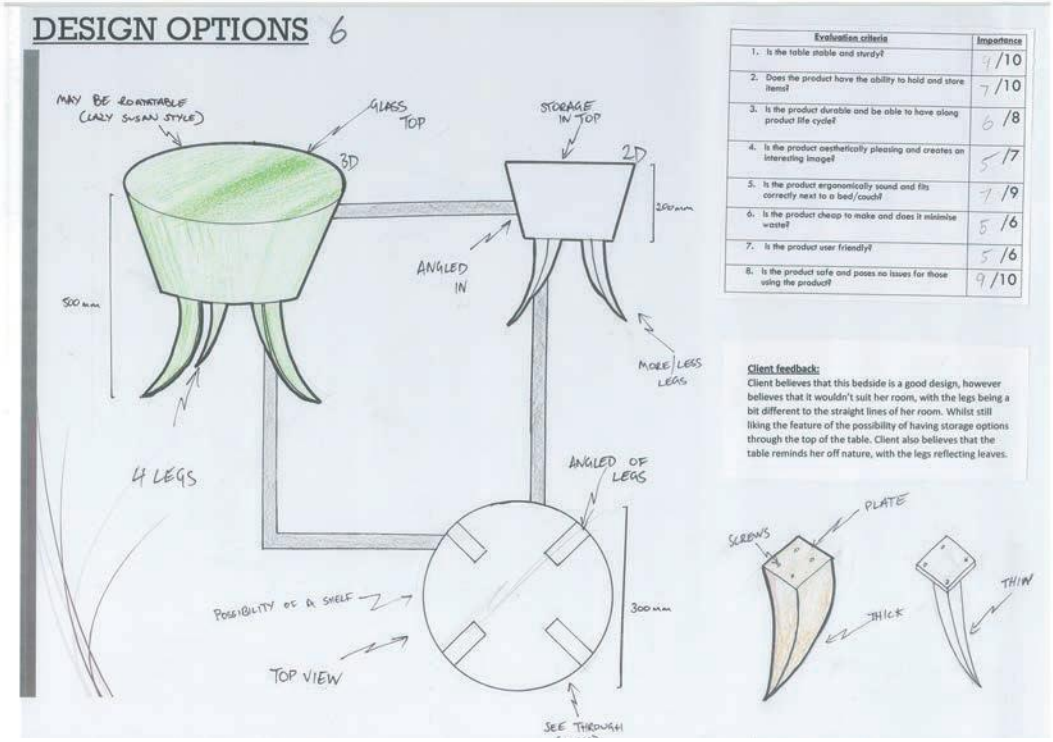
Orthogonal clock drawing ('Metamorphosis') by Angelica Milanes, displayed at Melbourne Museum in the exhibition Top Designs 2013 (part of the VCAA's VCE Season of Excellence 2013) and featured on p. 104 of the exhibition catalogue Top Designs 2013 (VCE Visual Communication Design, © VCAA 2013).

An orthogonal drawing for a clock by student Angelica Milanes

To purchase *Handbook HB1: 1994 Technical Drawing for Students*, go to the Sai Global website and use the search facility. A link to this website is provided at http://nelsonpdtvce.nelsonnet.com.au.



Orthogonal drawing for a coffee table showing front, top and side views by student Cullen O'Brien



As a design option, student Josh Goudge included a 3D drawing along with 2D views, some enlarged details, feedback from the user (his client) and evaluation criteria scores

Detail drawing

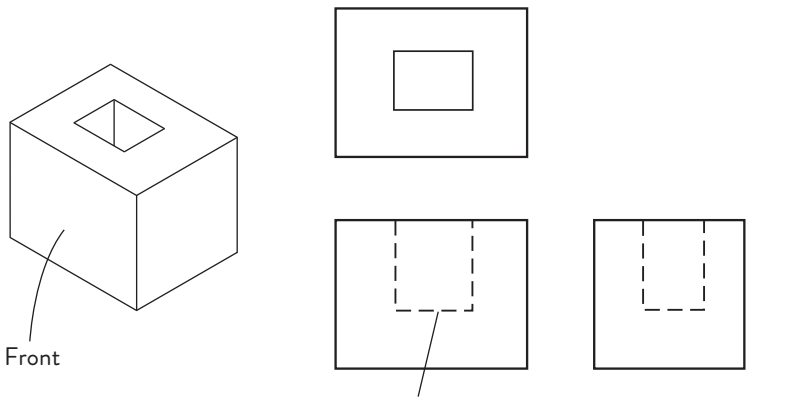
A **detail drawing** is helpful when a particular section of the main drawing is too small or its details are too complex for accurate representation at the chosen scale. Enlargement of that section – i.e. the production of a detail drawing – may become necessary. On a scale drawing, details are often drawn at five or 10 times the size of the original drawing, i.e. at a much larger scale.

detail drawing
a detail of the object drawn at a much larger scale than the complete object

Hidden detail drawing

On occasion it is necessary to see detail inside an object, or features that may be hidden because of the direction from which an elevation is drawn. To overcome this problem, **hidden detail** is shown using a thin (0.25 mm) dashed line.

hidden detail drawing
shows detail inside an object, or hidden features, drawn with a thin dashed line



Hidden detail is represented by thin (0.25 mm) dashed lines – approximately 2 mm line, 1 mm gap

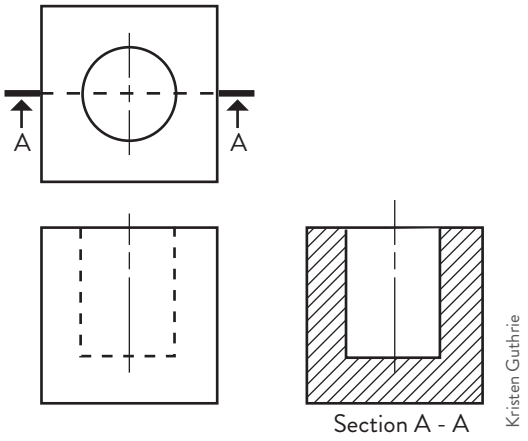
Kristen Guthrie

Section drawing

section drawing/ sectioning
a view of a slice through an object to portray its internal structure

Another method often used to show internal detail is **sectioning**. These may be full or half sections, depending on the object and detail required.

Sectioning requires you to imagine that the object has been cut through. Surfaces that are cut by the section plane are shaded with lines at 45° to indicate that they have been cut. These drawings can be very complicated, so it's important to check the 'rules' in the handbook.



Kristen Guthrie

Dimensions

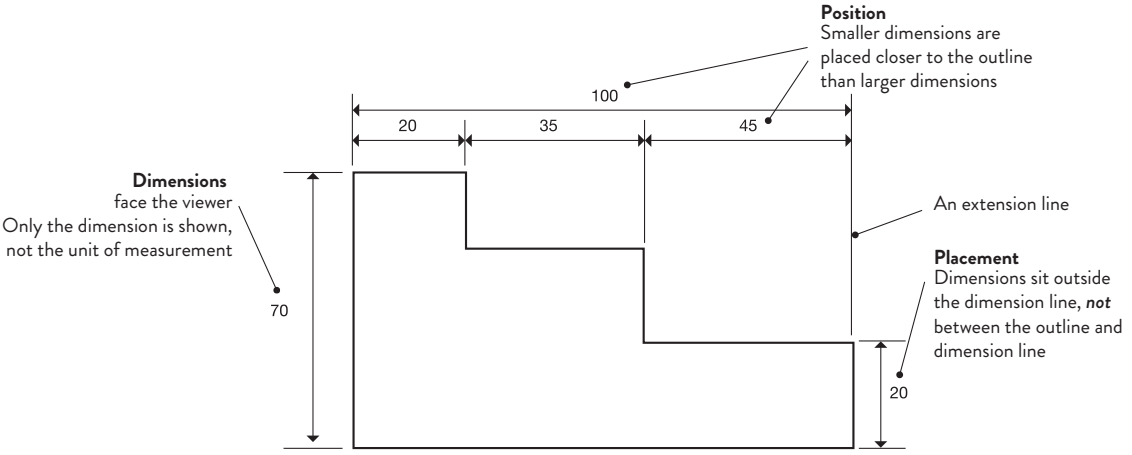
The various methods of indicating dimensions on your drawings are laid out in the *Technical Drawing for Students* handbook.

extension lines
light lines extending out from the object, defining the distance being dimensioned

Extension lines show the start and finish of the distance being dimensioned. They are drawn lightly and precisely. It's important that they do not touch the edge, so as to distinguish them from the object itself. An arrowed line, called a 'dimension line', is drawn from the start to the end between the extension lines, with the measurement written outside the dimension line. The dimension line is also faint and should be parallel with the edge of the object and drawn 10 mm away. Dimension and extension lines should be visibly lighter than the outlines, which are thicker and bolder.

Note that:

- all dimension lines require use of a ruler
- all dimensions should be written in the same direction and in millimetres, which must be indicated in the title block.



Kristen Guthrie

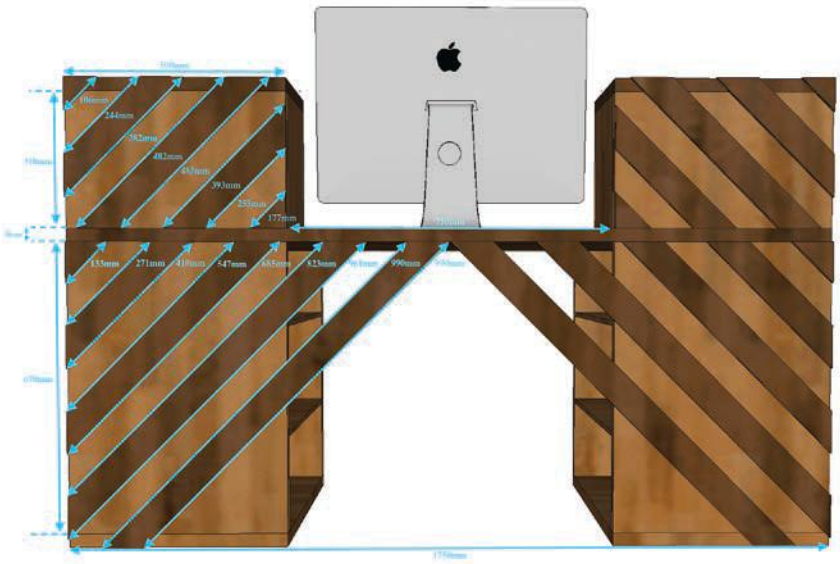
Indicating dimensions (in millimetres)

Computer-aided design (CAD)

computer-aided design (CAD)
programs that use data to digitally locate the points, lines and shapes of a design on X, Y and Z axes; 2D and 3D images of a design can be shown in perspective views, realistically rendered and rotated to display all of the design features clearly

Computer-aided design (CAD) programs are designed to handle objects in a 2D and 3D form. In many cases, this capability has removed the need for physical 3D modelling (discussed on the next page) in solid materials, particularly in the early stages of design refinement. Structural changes can be made, and surfaces and textures are clearly represented, without committing time or materials. If using CAD, create 3D rendered drawings for your design options and 2D (or 3D to aid communication) dimensioned drawings as working drawings.

9780170400336



Example of a CAD drawing by student Louis Edwards, showing the back view of a desk in 3D and with dimensions

The use of CAD is standard practice in industry because of its cost-effectiveness and additional benefits, which include the following:

- Drawings can be easily repeated with accurate calculations, or modified without re-drawing.
- Complex shapes can be produced and modelled and viewed in both 2D and 3D.
- Production and lead times are reduced.
- It is easily integrated with computer-aided manufacturing (CAM).

It takes many hours of practice for a designer to be able to use a CAD program effectively. Develop your CAD skills using software available in your school, or download and experiment with free drawing software, such as Google SketchUp.

Use of models

Communicating your ideas to others through the use of physical 3D models is a very effective way of visualising and presenting your ideas. Designers often use a model in combination with drawings when presenting initial ideas to clients.

Simple rough models help you explore shape, colour and proportion. A well-made model will represent the size, proportion and form of the object, along with other qualities, such as texture, surface finish, colour and pattern. They can be used to explore and critique ideas and to try out functional aspects. Some models are constructed from solid material blocks, and show the outward appearance and external details only. They are made of easily worked materials – such as cardboard, polystyrene foam or clay – or other materials such as aluminium, acrylic and plywood, and allow for quick and easy evaluation. Changes are easily made if required, and only a small amount of time and resources have been committed to their production.

Prototypes

Prototypes are used in mass production to check all external and internal details of a design before production. The prototype is tested, checked and adjusted, and the process is repeated. The final prototype is made to the exact specifications of the intended finished product (or parts). From a prototype, a designer can tell:

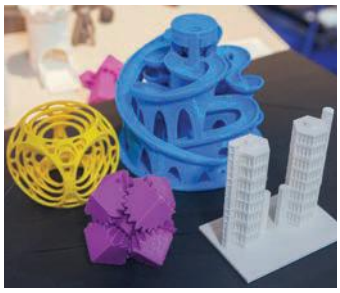
- whether the design will function as hoped
- if there is a need for further development
- the location of potential production problems.

prototype
3D full-scale version of a product used to test its performance before the product goes into production of multiples

9780170400336

3D printing

Some schools may have access to rapid prototyping equipment, for computer-controlled milling (subtracting from a solid block), 3D printing or laser sintering (using polymer powder that is melted with heat from a laser). To create physical objects, CAD files are needed. 3D printing is a great way to test dimensions of parts and how they fit together. It can also help gauge functional and aesthetic aspects to finalise details of the design before production.



Shutterstock.com/DmyTo

These objects were made using rapid prototyping

FABRIC, FIBRES AND YARNS

Suitable media

The following equipment can be used for drawing and design in the fabric, fibres and yarns area:

- pencils, pens, textas and watercolours
- body templates or croquis – basic body shapes used for the basis of drawings (but not permitted in the Units 3 and 4 exam)
- paper or fabric – different types can enhance designs, either as a background frame or for the drawing itself; paper is particularly useful for reflecting the colours, pattern and texture of the design – experiment with tissue paper, rice paper, textured paper and coloured paper; or mock up a design with shapes cut out of fabric
- clear plastic film (acetate) – to show layers of design, or to show annotation or comments without permanently cluttering the drawing (lots of writing on a design sometimes detracts from the drawn details).

Forms of drawing for textiles

Drawing technique	Purpose	Visualisations	Design options (presentation drawings)	Working drawings
Concept sketches; mock-ups and 3D modelling	To express ideas quickly for parts or whole of a product, either as drawings on paper or in 3D form			
Fashion illustration	Fluid drawings, giving a strong impression of a particular style			
Descriptive drawing	Clothing drawn on the body – clear, 8½ head proportions, including most details and colour			
Flats	Clothing drawn off the body – 'flat', front and back views, showing all details accurately			
Construction diagrams	Detailed diagrams explaining a construction step, showing seams and front/reverse side of fabric			

9780170400336

Visualisations

Start with quick concept sketches or 3D models and think laterally! Get down as many ideas as you can, to try out silhouettes, sort out details, work out functional aspects, and experiment with the design elements and principles. Aim to be inspired by products other than similar garments, and draw your ideas in close proximity to image/s that inspired you. *See pages 29–30 in Chapter 2*.

You can also draw **fashion illustrations**, which are usually very individual. This form of drawing is often used by designers to work through a range of ideas quickly (a form of drawing shorthand), focusing on the shape and outline, and some design features. When we see the design drawings of famous clothing designers, it is usually their fashion illustrations that are shown. Fashion illustrations are suitable and effective for initial sketching and brainstorming of ideas at this visualisation step of the product design process.

fashion illustrations fluid drawings used to give an impression of style, line and shape; they often have a strong sense of atmosphere and individual style

Fashion illustrations:

- use minimal lines to give an impression of the body, shape of clothes and fabric drape
- give details of strong design features
- may exaggerate or simplify the body or clothing
- may have a strong sense of movement (either through body position or through line drawing)
- give only impressions of fabric colour, texture and patterning
- give a strong indication of the style of the designer.

Using mixed media can enhance your visualisation drawings substantially. Instead of just using lead pencil, use pen to create bold outlines and add colour with washes, textas/markers, coloured pencils, textured rubbings, cloth or paper. Mock-ups or 3D models can be created with paper or with fabric and glue to try out proportions or combinations. Be sure to photograph and annotate this work to add to your folio. Aim for between two and four A3 pages of visualisations in your folio.

Creating visualisations with fabric and paper, by student Sian Banfield

Presentation drawings

Descriptive drawings

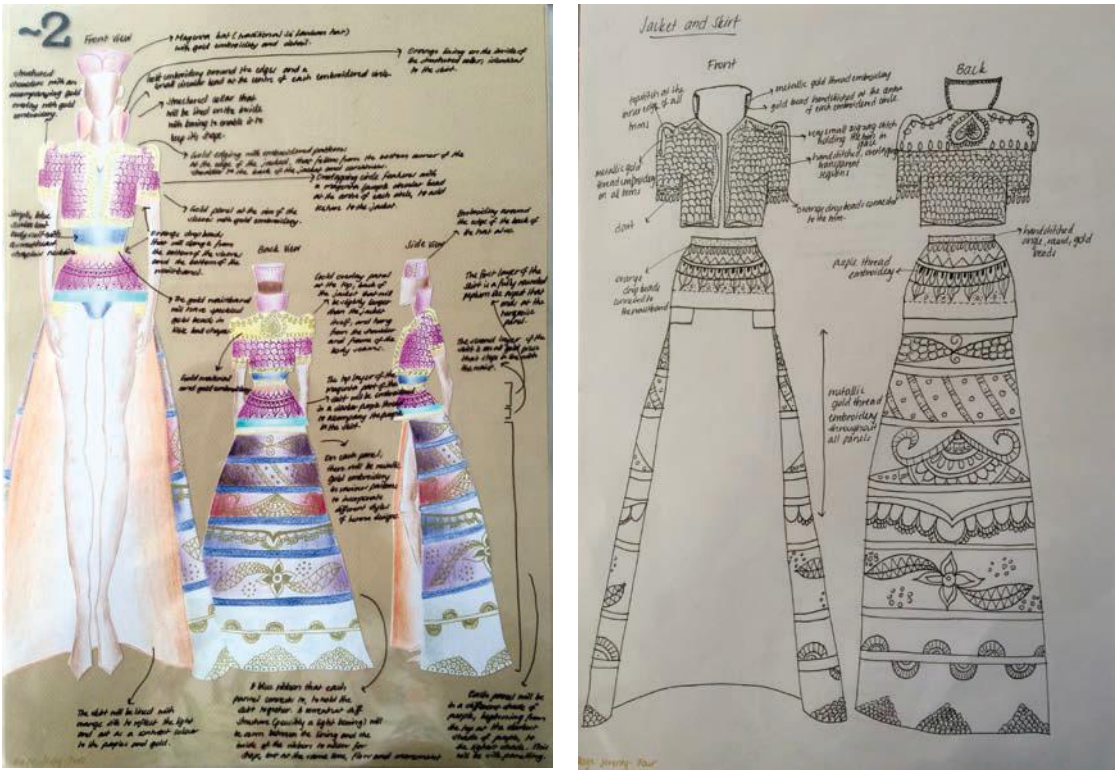
In **descriptive drawings** the body shape is clearly drawn. Use this form of drawing for design options. These drawings:

descriptive drawings clear drawings that give detailed information about the garment structure, fabric and colour

- provide clear, detailed information about body shape and features, clothing shape and style
- show seams, notions (zips, buttons, fasteners, etc.) and construction details
- usually show clothing from front and back
- usually have exaggerated proportions (long legs and body, wide shoulders, long neck and small head – the head goes into the body length 8½–9 times).

9780170400336

Two design options by student Laura McKenzie



The preferred design option in the presentation drawing style (left) and its working drawing (right) by student Isabelle Hanna

9780170400336

Body templates

Body templates are useful when completing fashion drawings, whether they be visualisations or descriptive presentation drawings. Body templates are outline drawings of figures in different poses. These can be enlarged using a photocopier, and then traced and used as a basis to 'dress' with your clothing designs.

Many body templates can be found online, but it is a better idea to create your own. This is also good practice for the end-of-year exam in Units 3 and 4, in which no templates are allowed. Once you have a template that you like, cut it out of stiff paper or cardboard and use this to trace around. A template of this type could also be 'dressed' in paper or fabric as a 3D model.

body templates
outline drawings of figures in different poses

Working drawings for non-resistant materials

The most suitable working drawings for non-resistant materials (fabrics, fibres, yarns, etc.) are:

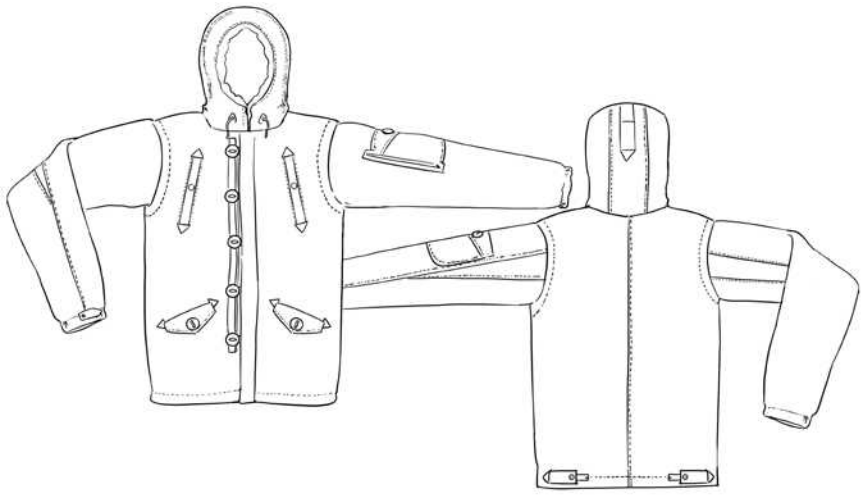
- 'flats' – to show the details of the design
- construction drawings – to show how the pieces are put together.

'Flats'

'Flats' are also called trade sketches or technical drawings. Designers use drawings of this type to illustrate their designs on a **specifications sheet** or 'spec' sheet. Flats may sometimes be used alongside a fashion illustration to provide detail that the illustration doesn't show.

'flats'
flat drawings, or trade sketches; they show the front and back view of clothing in great detail, off the body

specifications sheet
explains the details of a product to those who make it



A flat drawing of a hooded top

Construction drawings

Construction drawings are precise drawings of pattern pieces, or diagrams, that show:

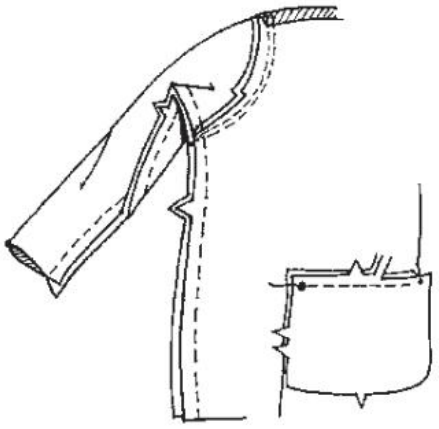
- stitching, seams, and the placement of zips, buttons, etc.
- details of equipment (as needed)
- enlarged details of difficult areas
- symbols for the alignment of pattern pieces, or the end of seams.

In construction drawings, the right side of the fabric is shown shaded, the wrong side of the fabric is shown white, and interfacing is shown hatched.

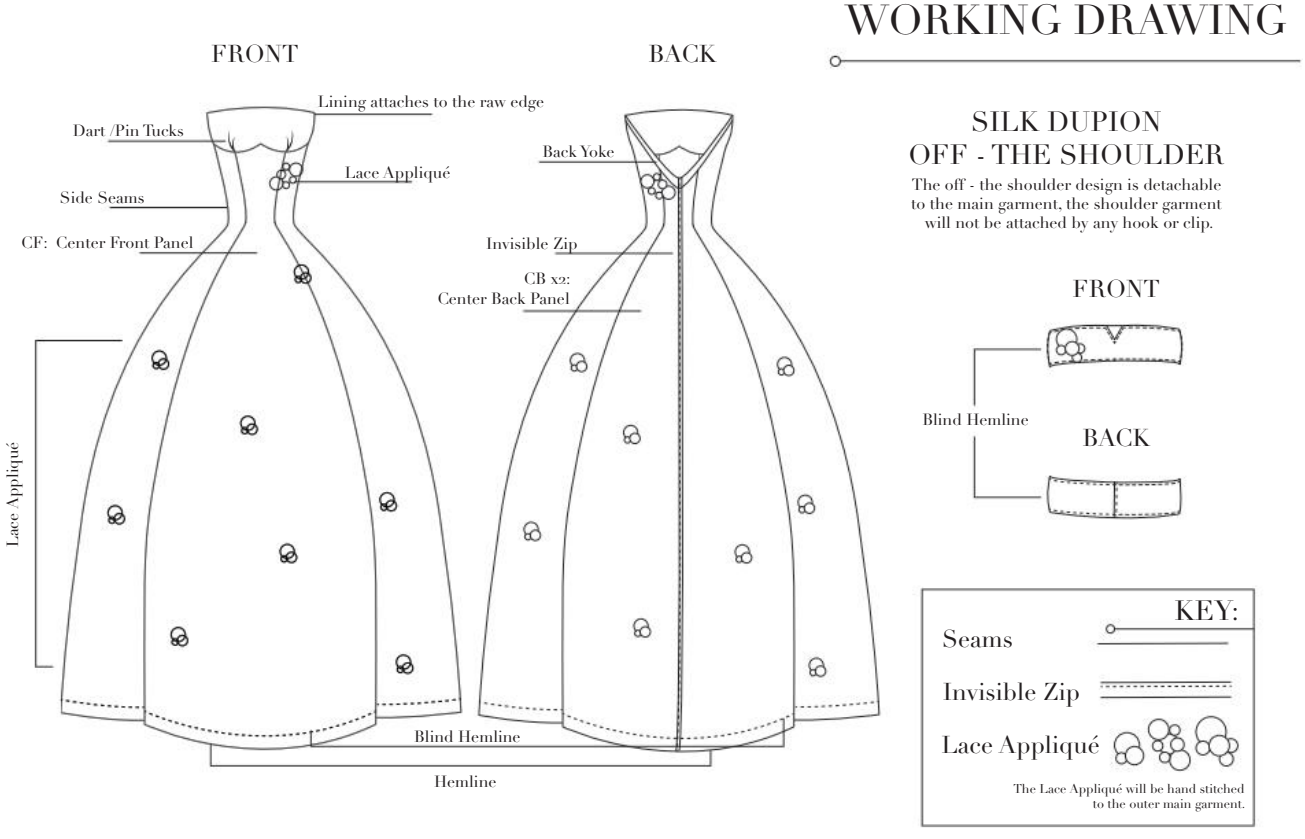
Construction drawings are usually part of a sequence of production steps. They are also often used in commercial patterns, to provide instructions to the maker. These drawings may only be required to show modifications to a commercial pattern. Check with your teacher to be sure of what is required and how you will be assessed.

construction drawings
drawings that show details of construction stages

9780170400336



Construction drawings, showing seam and pocket details



'Flat' technical drawing for a garment by student Cassandra Greenhalgh

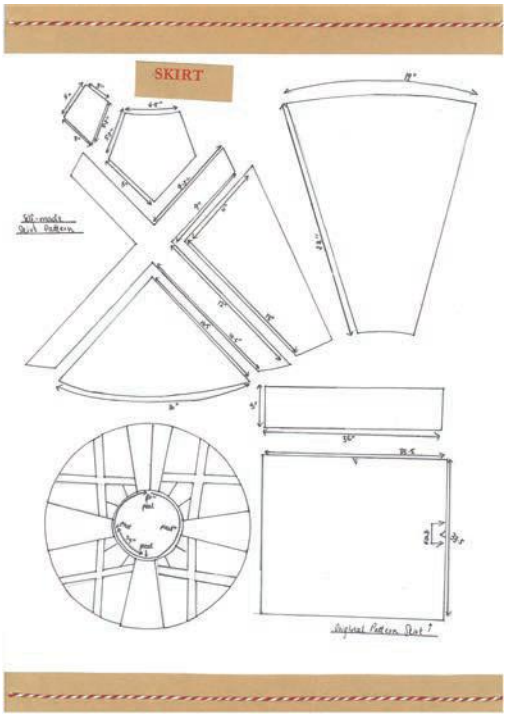
Modifying a commercial pattern

At VCE level you are permitted to use commercial patterns, but it is expected that you adapt them to reflect your selected design option and to fit the end-user. You will also need to consider the **layout** to minimise waste through the careful arrangement of pattern pieces on the fabric. Commercial pieces may be altered by folding, cutting and/or extending pieces to change the garment shape. These can be drawn as pattern modifications that show exactly how the pieces will be altered. See an example next page.

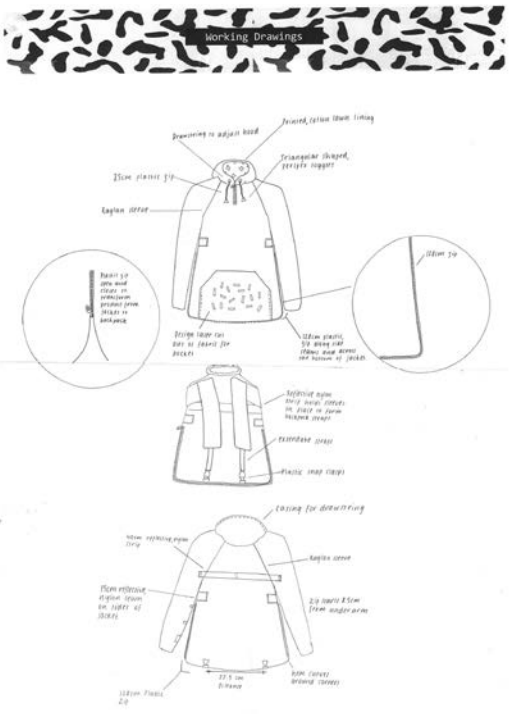
layout
the placement of pattern pieces on the fabric; planning for cutting

Check the Assessment Criteria for the relevant year on how your working drawings will be assessed for the SAT.

UNITS 3&4



Pattern drafting and adjustments by student Laura McKenzie



Working drawing with detail for a jacket/ backpack by student Sophia Loughrey

Computer-aided design (CAD)

For garments, there are CAD programs that have a series of body templates or real-life images stored. Clothing is shaped on top of these templates. Style, silhouette, colours, garment details, and fabric pattern and textures can be easily manipulated.

You can develop your own body templates in a drawing software package by digitally drawing or scanning a body shape into a program. Overlay the templates with garment shapes and experiment by filling them with patterns, colours and textures (either drawn or scanned).

Search online for tutorials on how to create 'flats' using Illustrator and other software.

Patterns, weaves, knits, textures and prints for fabrics can be planned using CAD programs. Information about fabric designs can be sent directly to printing, weaving or knitting machines via computer. Details can be swiftly changed, and the effects of those modifications can be seen immediately on computer-generated garment mock-ups.

For examples of how designers use CAD in garment design, see the case studies on Rip Curl (page 286) and at http://nelsonpdtvce.nelsonnet.net.au for Bonds and Metalicus.

Patterns, sizing and layouts

In industry, body measurement data is entered into pattern-making CAD programs, or a bank of standard measurements is used to 'grade' patterns. Grading means to create pattern pieces for a garment in numerous sizes. *For more information, see the Rip Curl case study on page 286.*

9780170400336

Fabric pinned onto a mannequin to check proportions and bulk, by student Michelle Dong

Modelling and trialling ideas

Ways of trialling fashion ideas are to:

- drape a small artist's mannequin with different fabrics, of different proportions or lengths, using pins or paper clips, to gain a 3D sense of the finished design
- create models from cut and folded paper
- cut out the negative space of a garment silhouette from thick card and place it over different fabric samples, for an idea of how the fabric might suit the style, or to check different fabric combinations. Take photos to add to your folio.

For other fabric products, you could create miniature bedroom or lounge furniture to trial soft furnishings for shape, colour combinations and fabric.

The most commonly used form of testing and perfecting a garment design is to construct a **toile**. The toile can be fitted and altered, and details can be changed, while it is on either a mannequin or a person. In fact, some designers start designing by folding and draping fabric directly onto the body form and using this as a stimulus to create their designs (called 'French draping').

toile
a full-sized version of the finished garment made out of an inexpensive fabric, such as calico

DESIGN AESTHETICS: THE DESIGN ELEMENTS AND PRINCIPLES

The design elements and principles are the fundamentals that give designs their aesthetic form:

- The **design elements** include shape, form, line, colour, texture, translucency, transparency and opacity.
- The **design principles** are concepts such as proportion and balance, symmetry and asymmetry, pattern, movement, repetition, rhythm, positive and negative space and contrast.

Many of the design elements and principles are closely interlinked. For example, it is very difficult to talk about pattern without discussing shape, line and colour. The following discussion of the design elements and principles talks about the concepts in an interrelated way, focusing on particular aspects of both areas.

design elements
the building blocks of design

design principles
the aspects that give structure and order to the elements of design

Line

Many features of a product's design create visual lines. These are not as simple to identify as, say, the pencil lines of a drawing, but they are present and our eyes recognise them. The features that create lines are usually the thin elements or edges of a product – the rim around a bowl, the edge of a shelf, the line of stitching that defines a collar, the organic line of a driftwood component, etc. Lines may be straight or curved; they may zigzag or spiral; they may be interrupted or they may flow through the product. Lines may also be used as part of a surface pattern. Designers can use the lines within their product to create movement, and draw the eye around the product or sweep it in a desired direction.

9780170400336

Shutterstock.com/Vladimir Wrangel

Shutterstock.com/Luba V Nel

Examples of the use of line: geometric lines in carved wood and top stitching on a leather jacket

Shape

Shape is one of the first things you notice about a product. It is a design element that helps you to visually distinguish one design from another. Designers can base their designs on geometric shapes, such as squares, rectangles, triangles and circles. These shapes are regular, and usually fairly stable and static in feel, depending on their proportion. Designers can also use organic or natural shapes. These are shapes that are found in nature – they are usually irregular and are often based on curves.

Some of the most satisfying shapes for design are based on an understanding and use of both geometric and organic shapes together. A designer can find the simplest geometric basis of an organic shape – e.g. the elegant spiral of a nautilus shell, or the balanced curves of a tulip bud – or they can use the contrast of the rigid stability of some geometric shapes with the flowing unpredictability of organic curves.

Shutterstock.com/joingate

Photos.com

Shutterstock.com/Jorge Moro

Some organic shapes may have a geometric basis

When designing a product on a page, it's easy to think in terms of the 2D shapes mentioned earlier, but when those designs are turned into products, shapes become forms – 3D cubes, cones, spheres, planes, etc. A simple shape or form can dominate a design because the eye finds it easy to recognise and classify. This gives the object a sense of visual unity. If lots of conflicting shapes are used, however, the eye becomes confused and tries to untangle the conflicting visual elements, leading to a 'fuzzy' image of the design.

9780170400336

form
the overall shape/s and structure of a 3D product

Shape and **form** interact with proportion to make an object appear to be heavy and solid, or light and delicate. Short, wide shapes – such as broad-based rectangles or triangles – suggest the concept of solidity, while tall, thin shapes tend to indicate delicacy and tension. The form a design finally takes is moulded by a combination of the designer's preference and the functions the product must perform.

Shape and form can relate directly to the primary function of the design. The primary function of a chair is to comfortably support the weight of a person above the ground in an ergonomically sound manner. This usually means that its structure must have some standard features – a surface to sit on and supports or legs of some kind. The designer has the flexibility to determine the size, number and shape of these features, and the materials used. Innovative designs, however, are ones that go beyond the usually expected features of a product and change its basic form while still allowing the product to perform its function.

Proportion and balance

Proportion can refer to two related aspects of a design:

- the relationship between the overall dimensions of an object – the length to the width to the thickness of the form
- the relationship between the size of, and space between, the various parts of a design.

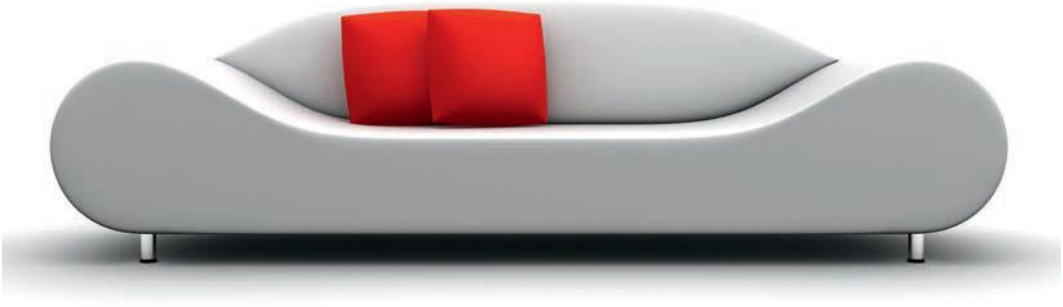
Stable proportions usually create a sense of balance between different aspects or parts of a product. Using similar or related dimensions for the component parts can make a product seem balanced or static. Some people find these related proportions satisfying – there is a sense that the object isn't going to fall over easily and is well grounded.

Golden mean

A commonly used series of proportions is based on the 'golden mean', a ratio that was used frequently in Classical Greek architecture. The golden mean relates to a mathematical series that was later defined by the medieval Italian mathematician Fibonacci; many of the ratios have approximately a 3:5 or 5:8 relationship. It has been suggested that this numerical relationship also occurs regularly in natural objects.

Many modern designers exaggerate some of the proportions of their designs for the effect that this produces. They choose dimensions that are very long and flat, or tall and thin, or one section might fly in a particular direction without seeming to be supported. This creates a sense of tension and instability or may focus on a particular feature. It also gives the sense of breaking away from expected or conventional forms.

Search for the work of the American industrial design teacher Rowena Reed Kostellow, who developed a very structured process of learning how to use 3D shapes to give visual structure to an object.



Shutterstock.com/Sebastian Kaulitzki

Creating an effect with symmetrical, exaggerated proportions and repeated forms

When thinking about proportions, it is important to consider the 3D forms that make up an object and how they relate to each other. If they are the same shape and size, this might be boring and repetitive. However, if the forms are of different sizes but with similar length-to-width ratios, this might give a sense of unity while being interesting.

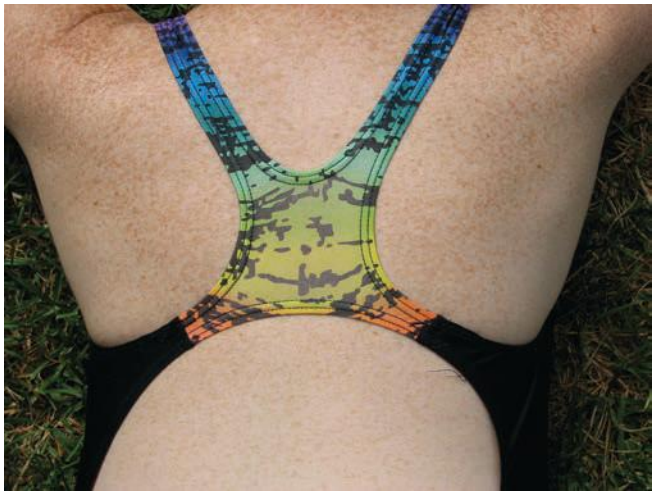
Symmetry and asymmetry

Symmetry is very closely related to balance. When an object is symmetrical, you can place a line through the centre and one side is the mirror image of the other. Some objects or shapes have more than one line of symmetry, and the symmetry lines can be vertical, horizontal and/or diagonal. So, you can see that if an object is symmetrical, it is very strictly balanced.

An object that is asymmetrical has no lines of symmetry. This doesn't necessarily mean, however, that the object isn't visually balanced – it might have different shapes with similar volumes to achieve balance, or the designer might use colour to provide balance and unity.

Positive and negative space

Positive space is the space an object takes up. Negative space is the area around the object, or spaces within or between parts of the object. For example, if you look at the back of a sporting swimsuit, the positive space or shape is the 'X' shape that the straps form across the back. The negative spaces are the elegant curved shapes formed between the straps. In a chair, the negative spaces might occur between the arms and the seat, between the legs, between sections of a back support, etc. It is very important for designers to consider the interplay between the positive and negative spaces.



istockphoto.com

Shutterstock.com/VikOl

Negative space – in a swimsuit and in a plastic chair

Visual bulk

Two products may have a similar basic shape, but a different use of materials and style will change how we read or perceive the object. For example, a table with a fine structure that utilises a steel frame with a glass tabletop tends to reduce the overall visual bulk by being delicate and transparent; while a larger, thicker opaque top and chunky legs on a timber table give a stronger, more solid appearance.

Using different fabrics in a garment also has a very large effect on visual bulk. This is partly to do with the transparency or opacity of the fabric, but is also affected by how the fabric falls –

its draping quality. For example, a shirt made from a thick, stiff, opaque cotton drill would have a very different visual presence to another shirt made from a flimsy silk organza.

Colour

Colour is a very basic element of design, and many art and design books will explain colour theory in depth. When discussing colour, we talk about:

- primary colours – red, yellow and blue
- secondary colours – orange, green and purple
- tertiary colours – e.g. brown and khaki
- the colour wheel – where colours are placed in sections of a circle to show their relationship to each other
- complementary colours – colours that are opposite each other on the colour wheel; highly contrasting, but often dynamic when used in design
- analogous or harmonious colours – colours that sit next to each other on the colour wheel, and are very soothing when combined (blue and purple, yellow and green, etc.)
- warm and cold colours (warm – reds, oranges and some yellows; cool – blues, greens, some purples, and some metallic colours)
- metallic colours
- other terms – such as hue, tint and shade – to describe the subtleties of colour mixing and the addition of black and white to make colours lighter and darker
- the way colours create mood and evoke emotion, and can transport us to different places (spicy rich reds, oranges and purples may make us think of the heat of India or Morocco, while cool aqua and pale cream/yellow may evoke a holiday on the beach).

Colour is affected by tone – how light or dark a colour it is. Contrasts or differences in tonal value provide interest and depth in product design. Colour also means different things in different materials. When using fabric, for example, discussions of colour are both straightforward and open-ended – all colours are possible, and can be used in an endless variety of ways and combinations.

Shutterstock.com/Gina Smith

Shutterstock.com/archideaphoto

Examples of products and clothing and how they use colour

When making products from resistant materials (i.e. wood, metal, glass and plastic), however, discussions of colour are driven by the particular material being used. Metal and timber have a limited range of natural colours, but the surface of these materials can be altered, painted or coated to increase the variety of colours. Glass and plastic can be sourced in an unlimited colour range.

To find out more about colour and resistant materials, go to pages 82–3. For fabrics, go to page 85 and Chapter 9.

Colour is affected by the degree of transparency of the material. Materials can be transparent (see-through), translucent (partly see-through, or cloudy) or opaque (completely solid). If a material is transparent or translucent, its colour will be affected by the colours behind it. This can be used to great effect – think of layering gauze-like fabrics, or overlapping sections of tinted plastic or glass. Philippe Starck used the quality of transparency dramatically in his *Ghost* series of designs.

The suitability of a colour depends entirely on the overall image and purpose of the product being designed. Fluorescent colours, for instance, project a very different image to beige or pastels. Colour can be used subtly – in light washes, harmonising and blending shades. Or colour can be used dramatically – creating visual tension by combining strong and contrasting colours. Colour can be used to emphasise the shape, proportion and details of a product, or it can be used to camouflage those aspects.

Alamy Stock Photo/Elizabeth Whiting & Associates

Philippe Starck's *Louis Ghost* chair and table

Texture

Texture is both a visual and a sensual aspect of design, and usually refers to the materials used in a product. It relates to both the look of a material and its feel. The sensual cues to texture might be that the surface is rough, smooth, furry, corrugated, slippery, etc.

When talking about the visual aspect of texture, we usually refer to the **sheen** of a material or its finish. Texture can also relate to a pattern that is applied to or is part of a material. For example, the heavily cabled pattern of a knitted fabric will give it a variegated texture. A finely etched pattern in metal has a bumpy surface, and the pattern also interrupts the play of light on the surface of the metal.

sheen
how light is reflected by a surface

Shutterstock.com/Oleg_Mit

Shutterstock.com/Oksa

Examples of the use of texture: knitted fabric and textured metal

Point

In product design, point relates to a particular place or spot that the eye is drawn to that is isolated or by itself.

Contrast

Contrast can be achieved by different colour, materials and textures being placed close to each other. Contrast can be a part of other principles such as balance or pattern.

9780170400336

Shutterstock.com/NINUN

123 Royalty Free/Дмитрий Гооль

Examples of the use of regular and irregular patterns in the slats of a chair and in a retro-style fabric

Pattern and rhythm

Pattern usually refers to a surface decoration on the materials used in an object, although it can also refer to a repeated feature that creates a visual pattern. In clothing, pattern is often a printed design produced in various colours, shades or textures on a roll of fabric. However, something like a twisted pleat that is used repeatedly could also create the effect of a pattern.

Pattern is often created by repetition of a motif or shape. Repeated patterns create a sense of rhythm that is predictable, like the rhythm of a piece of music. On fabric, the same unit of surface design used many times along the length of the fabric is called the repeat of the pattern.

The shapes or sizes of the forms within an object may be the source of some patterns. These forms may all be the same shape and size – e.g. the slats on the back of a chair – and will give the object a unity and rhythm. Or the forms might gradually change, still being similar in shape or nature, but with the gradual change adding interest and movement.

Some patterns, particularly those that occur in nature, are not regular. The figuring of the grain in a piece of timber, or the irregular markings of fur or some other fabrics are still thought of as patterns. They have unifying features, but the many parts of the pattern are not identical.

Shutterstock.com/Baloncici

Natural irregular patterning: faux fur

Movement and rhythm

The word 'movement' means different things in different materials and objects. When discussing clothing, the term usually refers to how the fabric flows and drapes. When looking at other objects, such as furniture, it refers to how the eye is drawn across the object by its visual features. In other objects, a repeating pattern, a delicate sense of balance, or parts that stretch outwards or upwards can create a sense of movement and/or rhythm.

Style

The overall effect and interaction between shape and proportion, colour, pattern and texture create the style of any design. Designers often have a particular 'style', because certain ways of using the design elements appeal to them and they use these stylistic features repeatedly.

To find out more about specific furniture and fashion styles, go to Chapter 11.

Style can often be categorised as either 'modern' or 'traditional', 'minimalist' or 'cottage', etc. There are also certain styles that relate to a period, or to groups of designers. What defines a style is the similarity in the way the design elements and principles are used.

USING DESIGN ELEMENTS AND PRINCIPLES: WOOD, METAL AND PLASTICS

The information discussed in the previous section refers to products made of many different materials. The following section focuses on furniture, but is applicable to any product.

Shape and proportion

When considering shape, it is important to think about the overall general shape of an object (the outline or silhouette) and the shapes of the different parts that make up the whole.

It is very easy when working with timber, metal and plastic to limit the shapes used in design to squares and rectangles. These are the most straightforward shapes and forms to construct, as these materials come in flat, straight sections, and it is more complex to transform them into curves, circles, spheres, etc. However, this limits design choices to a reduced range of geometric shapes. This doesn't mean that effective designs can't be created from rectilinear shapes; it just means that if organic forms are not considered, design choices are restricted and the possibilities of interesting interactions between geometric and organic are not available. So, designers need to be open to construction processes that make the formation of a wide range of shapes possible.

An interesting example is the Belkiz *Feedaway*, a portable high chair that uses a combination of simple geometric shapes that contribute to its functions of being stable, easy to clean and easy to fold away. You can find photos of this product online.

Alamy Stock Photo/Andreas von Einsiedel

An interesting interaction between geometric and organic: the Eames *La Chaise* chair

9780170400336

Experimenting with shapes

When sketching design ideas, you might find it helpful to choose three simple shapes – these might be the same basic shape, but in different sizes; or they might be three different types of shapes, e.g. a semicircle, a triangle and a rectangle. Play around with these shapes on a page – place them in different positions, change their size relationships, connect them in different ways, etc. Now look at the interaction between the shapes you have drawn. Which drawings are stable? Which are imbalanced? Which give a sense of tension? Which shapes dominate? Which drawings are boring – and why? Think about how the shapes can be used to fulfil the function of the product effectively, but in different ways. Then try exploring the possibilities of other shapes.

Colour

When discussing the colour of metal and wood, we can sometimes feel restricted by the range of colours that naturally occur in these materials. For example, there is a limited range of metallic colours, ranging from silver to bronze (note that terms such as 'bright' and 'dull' are used to describe the colour and sheen of metals); while the colours that naturally occur in timber mostly range from very pale cream, through to reds and browns, to dark brown and black (although there are also some strikingly coloured purple and orange timbers).

Metals can be:

- chemically and physically altered to give a broader range of colours – copper can be oxidised or heat-treated to produce different colours (greens and browns), and aluminium and titanium can be anodised to produce a huge range of colours
- powder-coated or painted in an unlimited range of colours.

Alamy Stock Photo/WENN Ltd

The Memphis-style *Carlton* bookcase, by Ettore Sottsass

Timber can be:

- stained and tinted to broadly increase the range of colours available – from fairly natural colours to brightly coloured stains that still allow the timber grain to be seen (don't forget that different types of finishes affect the end colour of the timber used in different ways)
- painted to change its surface colour.

Plastic is extremely versatile in terms of colour. Plastics are available in a wide range of 'ordinary' colours, fluorescent colours, mirror finish, etc. Plastics are also available in transparent, translucent and opaque forms, which provide still more colour possibilities. Laminate is also considered a plastic material (it is usually used to surface a timber product), and it, too, comes in a wide range of colours, textures and patterns or effects.

When considering colour during the design process, it is important to think about what you want the colour to achieve. Do you want the object to blend into the background – if so, do you need to match the colours to other objects it will be close to? Or do you want to use colour to make the designed object grab people's attention – if so, what colours will provide a strong contrast when

compared to other objects? Different colours can also be used on different parts of the product to create contrast.

The style of the product can also determine the range of colours that might be used – e.g. bright, painted colour surfaces for Memphis-style furniture, sleek metallic colours for minimalist or industrial-looking furniture, and rich red-brown timber colours for more traditional designs. Look at the work of designers such as Rittveld to see how colours and shape can be used to create strong impact.

Pattern

Pattern often means a different thing when discussing timber than when it is used in relation to metal or plastic. Because metal and plastic are highly processed, they are usually uniform in appearance and don't have any inherent patterning (unless it is pressed or embossed). Most patterns need to be added during construction.

Patterns can be added to metal (and sometimes plastic) by:

- scratching or etching the surface
- using techniques such as **mokume** that layer, press and then grind back to reveal different layer colours
- creating Damascus steel by welding several types of steel and iron slices together to form a billet – used for knife blades
- using qualities such as plastic memory, e.g. pressing, sanding flat, and then heating to raise the depressed surface so that the sanded area forms a pattern
- using chemicals to affect the surface
- adding a painted or enamel patterning to the surface.

mokume
layers of metal laminated together, then manipulated and ground to show the patterns created by the layers

Timber often has inherent patterning of grain lines and **figuring** (including beautiful wave-like and birds-eye figuring). Often the most highly prized pieces of timber are those that have the most decorative figuring or grain patterns. Very thin veneers of these timbers can be attached to the surface of other timber products (such as MDF or chipboard) to extend their use. Some figuring can be almost regular, but most are random and erratic.

figuring
lines created by the grain patterns in timber

Handmade yellow gold, white gold and sterling silver mokumé gané pendant on peridot necklace by Venetia Major of Venetia Major – Bespoke Jewellery

Shutterstock.com/reddees

Different types of patterns on metal and wood – mokume and carving

9780170400336

Patterns can be added to timber by:

- carving, cutting or burning into the surface
- painting a pattern onto the surface.

Some glass has inherent patterning created by different colours or changes in opacity, and these are produced during the processing stages. In addition, surface patterning and texture can be formed by moulding molten glass or by etching the glass surface.

Shutterstock.com/Ilya Andriyanov

Patterned glass

USING DESIGN ELEMENTS AND PRINCIPLES: FASHION

The section on design aesthetics begins on page 74, and discusses items made from fabric, as well as from wood, metal and plastics. However, there are sometimes specific ways of interpreting the design elements and principles that relate to fashion and clothing.

Shape, proportion and balance

silhouette
the outside shape or outline of the garment or object (without any internal detail)

When discussing fashion and clothing, shape can refer to two things:

- the overall shape of the garment, outfit or accessory – its **silhouette**
- shapes that are used as components of the garment or object (e.g. a sleeve or collar), or that are part of the fabric's graphic design (e.g. as part of a printed pattern).

Simple white shapes to create form, and use of line to emphasise them, in a Gucci handbag

The silhouette shapes related to fashion include:

- the tube – long, cylindrical and narrow, with minimal shaping
- the box – very square, wider than the tube
- the trapeze – a triangle with a wide base, and pointed or narrow at the top
- the bell – narrow and tube-like in the top section, suddenly rounding out to a flat base
- the hourglass – wide at the top and bottom, and narrow in the centre
- the wedge – an inverted triangle, wide at the top, narrowing to a point at the bottom.

The silhouette is affected by shaping the waist, the shoulder line, and the fullness of the skirt (if there is one), etc. We often think of fashions of a particular era as using a specific silhouette shape – e.g. the tube-like flapper dress of the 1920s, the full-skirted, bell-shaped ball gowns of the 1950s, and the wedge created by the padded shoulders of 1980s power dressing. *To find out more about silhouettes in fashion styles, go to Chapter 11.*

There is less variety in the shaping of men's clothing. Men's clothing is usually based on boxy shapes, and changes to the silhouette are more subtle.

Shapes used for the components of a garment are usually geometric in their basis – e.g. the triangle of a collar, the semicircle of a puffed sleeve cap and the elongated rectangle of a box pleat. Understanding how these shapes are formed over a 3D body – and using the shapes to exaggerate, enhance or alter perceptions of body shape – takes lots of skill and experience.

Shapes can also be used to pattern fabric. The size, colour and scale of the shape will have an effect on the look of the garment and how it is perceived. Different types of patterned shapes are often related to eras and fashion styles – e.g. the strong, bold, geometric shapes of the 1960s, and the teardrop shape of paisley, which was popularly used on late 1960s and early 1970s 'flower power' clothing. *To find out more about the impact of patterning, go to page 87.*

Shutterstock.com

Men's clothing is usually based on boxy shapes.

Colour

When discussing clothing, some colours are categorised and given a group name:

- neutral colours – greys, cream, beige, black, brown
- classic colours – navy and royal blue, red, mid–dark green
- pastel or gelati colours – pale tints of pink, lemon, green, blue
- natural colours – the same as neutral, but also including ochre, terracotta, brick red, etc.
- spicy colours – strong yellows, reds, oranges
- jewel colours – crimson, purple, emerald green
- metallic – silver, gold, bronze, etc.
- fluorescent – bright orange, yellow, green, blue, pink
- jungle colours – greens, browns.

Some people also talk about colours that reflect different seasons – sombre, dark colours for winter; fresh, bright, 'living' colours for spring; bright, strong colours that reflect the sun and beach colours for summer; and rich, warm tones for autumn. 'Colour blocking' is a term used to describe the use of flat, loud colours for the whole or sections (blocks or panels) of a garment.

Shutterstock.com/Natalia Mikhaylova

Striking use of spicy colours in a Manish Arora collection

9780170400336

National Gallery of Victoria/Martin Grant Collection Paris

Straight lines and clear angles on the *Stitch Coat* by Martin Grant

Line

Lines in clothing can be part of the construction of the fabric or patterning of the fabric, but lines can also be formed by seams, the stitching and folding of fabric, and other aspects of the construction. These lines can define the shapes within the garment.

The direction and strength of the lines have an effect on how we 'see' the clothing. We all know the trick that vertical lines make the body look longer, taller and slimmer, and that horizontal lines do the opposite. If a line is uninterrupted, the eye flows easily and is drawn along in the direction of the line, whether the line is a feature of printed fabric or part of the garment's construction. If the line is interrupted, the eye stops and focuses on where that interruption occurs.

Lines can also give character to a garment. Straight lines and clear angles give a sense of structure and order. Curved lines are connected with grace and sensuality. Lots of construction lines or linear details create clutter and distract the eye, while fewer lines or regular repeating lines create a sense of the garment being streamlined.

Texture

The look and feel of a garment or fabric product is often determined by the texture of the fabric that it is made from. Fabric texture can be rough, grainy and stiff, or it can be smooth and shiny.

The texture of a fabric is governed by the way it is constructed (the density and pattern of weaving or knitting) and the fibre or yarn it is constructed from (whether it is fine or coarse, smoothly spun or knobbly). A change to the surface might also give the fabric texture (e.g. corduroy, embroidered, pressed, creased or burnt patterns). Some people talk of the sound of texture – the swish of silk taffeta, or the 'scritching' of a raincoat as you walk.

Shutterstock.com/Milos Luzanin

Corduroy

Shutterstock.com/llaszlo

Silk

9780170400336

Pattern

Patterns use the elements of line, shape and colour in a repeated way, and are an important element in clothing or fabric product design. Designers use patterns to give their designs interest and drama.

Patterns can be either formed in the construction of the fabric – the interplay of threads as they are woven or knitted – or printed or embroidered onto the surface.

Shutterstock.com/llaszlo

A pattern formed in the construction of the fabric: cable knit

Patterns formed in the fabric construction

Patterns that are woven into fabric with different colours often have specific names, e.g. plaids, herringbone and hound's-tooth; while twills and jacquards are fabrics with a pattern formed from threads of the same colour, which are woven using changes in the **warp** and **weft** threads.

Patterns can also be part of the construction of a knitted fabric. Different colours can be knitted to form traditional 'Fair Isle' patterns, or more modern patterns. Or threads of the same colour can be knitted to form textural patterns such as 'Aran' and functional ribbing patterns. Complex machine knitting uses colour and texture to create a multitude of pattern options and fabric construction.

Transparent and opaque sections of fabric can also be used to create delicate patterns in lace and thermal/chemical burnt-out fabrics, while pressing into a fabric with a raised pile can create the type of patterning that is evident on crushed or panne velvet. Ikat fabric uses a traditional way of creating patterns – it is formed by a combination of dyeing and weaving.

warp
the structural threads of woven fabric that are threaded onto the loom and run along the length of the fabric

weft
the 'filling threads' that are woven from side to side across the warp

Printed patterns

Many different shapes can be used in printed patterns, e.g. geometric shapes, such as squares, circles, dots, stripes, zigzags and teardrops.

Shutterstock.com/wikki

An African semi-abstract pattern

iStockphoto.com/Bkkwekender

An Indian printing block

9780170400336

abstract pattern a non-representational, non-pictorial pattern

naturalistic/ figurative pattern a pattern based on a recognisable thing (may be realistic, simplified or stylised)

- **Abstract patterns** are not based on a real or figurative image – they use geometric or random elements.
- **Naturalistic** or **figurative patterns** are based on real things – e.g. flowers, fruit, people and figures, and planes and cars.

The unit of the image printed onto fabric is called the repeat, and there are different ways of repeating a printed image along a roll of fabric. A pattern unit can be:

- repeated in a corresponding position, so that the same features line up and are very regular
- offset, so that the repeat is less obvious, the features don't line up, and the pattern flows more continuously.

Using patterned fabric

It is important when designing and making an article out of patterned fabric that you think about the pattern when you are cutting out. If the pattern has large and/or prominent shapes and colours, pieces need to be placed very carefully before cutting. This is so that parts of the pattern match up at obvious joins in the garment, such as the centre front, back, side and shoulder seams. Having a pattern that can only be used in one direction also affects cutting out – you need to allow more fabric in these circumstances, so that you have the flexibility to move garment pieces around to find a good match for seams.

There used to be strict conventions that limited the mixing of different patterns, but now many contemporary designers use overlapping layers of complex and strong patterns to great effect. This can be seen in some of British designer Vivienne Westwood's work, in which she combines vivid and clashing tartans that previously would not have been seen in the same garment. *To find out more about the work of Vivienne Westwood, go to page 328.*

Style

Design features, colours, clothing lengths, fabrics, etc., go in and out of fashion, and commercial designers need to be aware of the latest trends. However, many exclusive or boutique designers have their own particular way of interpreting trends. Or they may ignore the transient trends completely and concentrate on expressions of their own 'style'. For example, the work of Australian designer Martin Grant (now based in Paris) is easily recognised. He has had a fairly constant approach to the way he structures his garments, and the range of colours he uses. *To find out more about Martin Grant, go to page 307.*

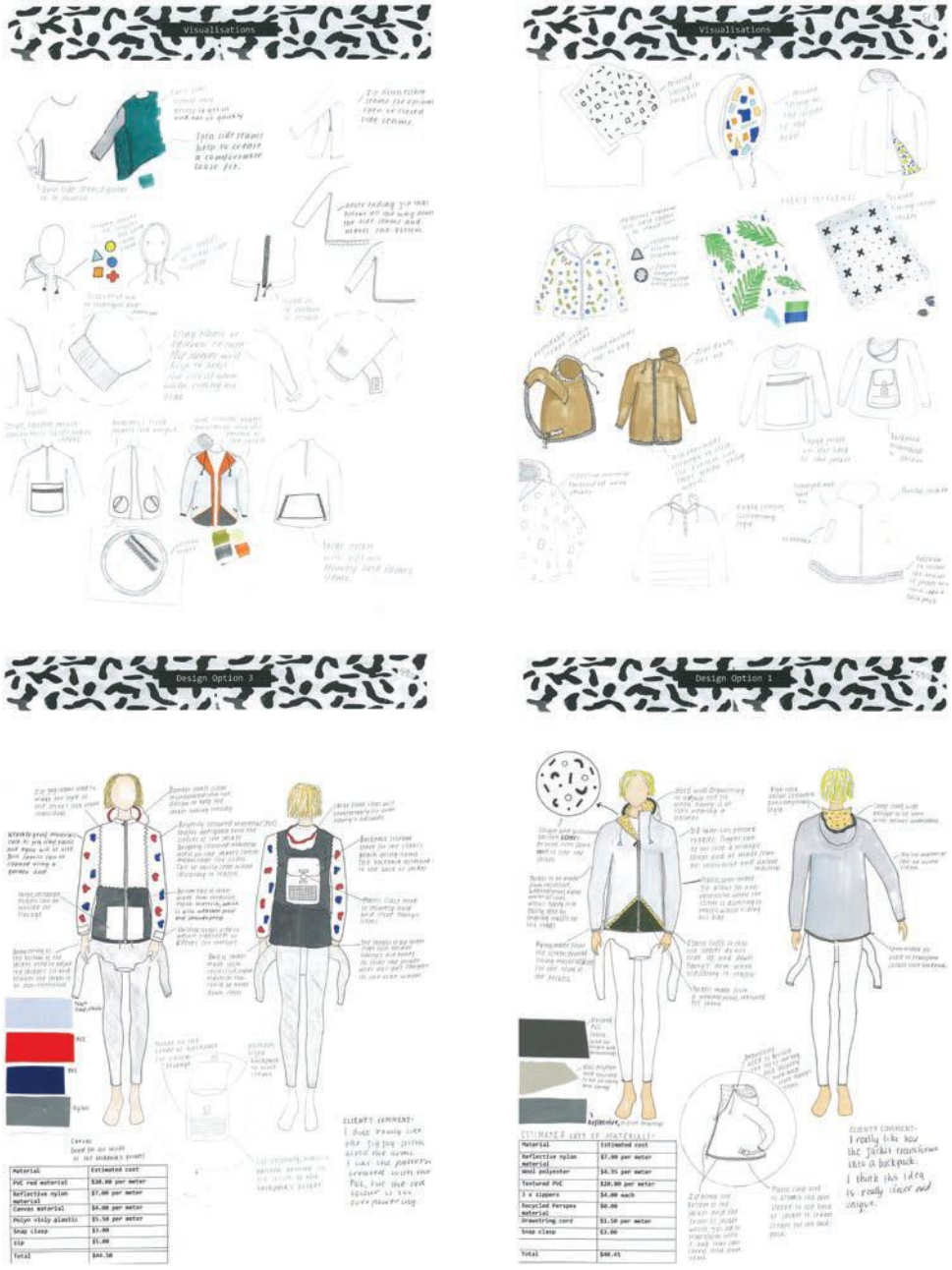
Features that make up the style of a garment or clothing range include:

- shapes, fit and 'cut'
- level and types of detailing
- fabric choices – fabric categories, qualities, print or plain or combinations
- use of decoration
- colour palette
- proportions of the component parts, which are affected by the length of sleeves, skirt and pant legs; placement of waistline, etc.
- stimulus for design (themes).

9780170400336

Designers sometimes talk about having a 'design story' or stimulus that inspires a fashion range – this could be an exotic place or culture, a past era, or decorative qualities from a different medium. Aspects of these 'stories' will be reflected in most or all of the features of design. For example, a designer might be inspired by the clothing and culture of India. This would reveal itself in loose shaping and lots of folded and wrapped construction to reflect Indian clothing styles. Fabrics would be highly decorative and brightly coloured, often in spicy, rich tones. Inspiration for these choices are often researched and put together in the form of 'mood boards'. *To revise mood boards, go to pages 56–7.*

Go to your student website at http://www.nelsonnet.com.au and use your login code to access the downloadable smartphone revision cards for drawing types.



Folio pages with visualisations and two design options for a jacket that transforms into a backpack by student Sophia Loughrey.

Shutterstock.com/Diego Cervo

CHAPTER 4 Product design factors

CHAPTER FOCUS

In this chapter you will learn about product design factors:

- Purpose, function and context – including primary and secondary functions, functionality and quality p. 92
- User-centred design – including inclusive design and ergonomic factors p. 96
- Innovation and creativity p. 102
- Visual, tactile and aesthetic factors p. 103
- Sustainability – the interconnectedness of economic, environmental and social dimensions, and the supply chain p. 104
- Economics – cost and time p. 107
- Legal responsibilities – intellectual property, Australian and International Standards and OH&S p. 108
- Materials – suitability, characteristics, properties and compatibility p. 114
- Technologies – conversion techniques and processing methods p. 116

PRODUCT DESIGN FACTORS

The following factors and their parameters are in the cross-study specifications of the *VCE Product Design and Technology Study Design 2018–2022* (page 11), which means that they are essential knowledge for all units and outcomes. These factors underpin and influence all design and designers. Almost all of the factors are present in some way in every design.

In VCE you can refer to this list:

- to assist you in writing design briefs
- when working through the design process
- when analysing products and designs produced by others, and when looking at how design occurs in mass production, to see how the factors have been addressed.

As you become familiar with these factors, you will see that there is quite a lot of overlap between them, e.g. materials can relate to the aesthetics and texture of a product, its function and quality, as well as its sustainability.

9780170400336

Product design factors	Parameters
Purpose, function and context	Includes the reason or need for a product, in the context and environment of its use. This includes its operation, performance, reliability and quality. The primary and secondary functions that support its use are considered.
User-centred design	End-user/s' problems or needs identified to improve well being and quality of life: cultural and religious considerations, age, economic status, emotional and sensory appeal, universal design, social and physical needs, fashion and trends are considered in response to these needs. Safety, accessibility, comfort, ergonomics and anthropometric data should also be considered.
Innovation and creativity	Innovation requires a creative approach to develop new or improved solutions to unsolved problems or opportunities. This involves invention, improvement, modification, incremental progress, experimentation and pushing the boundaries. Opportunities are identified from research and development, user feedback, new ideas/knowledge, new materials and emerging technologies.
Visual, tactile and aesthetic (design principles and elements)	Relate to the product's form, appearance and feel. Design elements include point, line, shape, form, texture, tone, colour, transparency, translucency and opacity. Natural forms, patterns and structures along with geometry and mathematics can also be employed to create aesthetic appeal. The design principles of balance, contrast, repetition, movement/rhythm, pattern, proportion, symmetry/asymmetry, negative/positive space and surface qualities are used to combine and arrange the design elements.
Sustainability	Involves the connection and interaction between three pillars of sustainability: social, economic and environmental systems. Underpinning aspects include Life Cycle Analysis/Assessment (LCA) and life cycle thinking, emotional attachment, carbon footprints, embodied energy and water use, distribution (product miles) and use of renewable energy and resources.
Economics – time and cost	Costing a product takes into account materials, labour and use of plant (equipment and machinery) but must give value to the end-user/s. Time management and material availability are critical issues to consider.
Legal responsibilities	The legal aspects of product design are: intellectual property (IP), particularly Patents and Design Registration; Australian and International (ISO) Standards, regulations and legislation (including OH&S or WHS). Products must be produced safely and be safe for the user.
Materials – characteristics and properties	Materials appropriate to this study are listed on page 12 of the Study Design. Materials are selected for use based on their properties (their performance and behaviour both chemically and physically under certain conditions) and characteristics (visible features). These properties and characteristics include: strength, durability, thermal resistance, hardness, density, rigidity, flexibility, corrosiveness and compatibility with other materials.
Technologies – tools, processes and manufacturing methods	Conversion techniques (changing raw materials into useable forms) and production processes are reliant on and affected by available tools, equipment, machines and expertise. Suitable and accurate methods are selected to perform the following: marking/setting out, cutting/shaping/forming, joining/assembling/constructing and decorating/embellishing/finishing.

Extracts from the VCE Product Design and Technology Study Design 2011–2016 are copyright of the Victorian Curriculum and Assessment Authority (VCAA) and have been reproduced with permission. Please see the VCAA website for more information: http://www.vcaa.vic.edu.au

9780170400336

PURPOSE, FUNCTION AND CONTEXT

Some of the most basic questions to ask about a product are 'What does it do?', 'What is it for?', 'What is its purpose?', 'Why is it needed?' and 'What is its function?' While these questions are worded differently, they all refer to the same thing. We will look at purpose, function and context from the perspective of:

- primary and secondary functions
- functionality
- operation, performance and reliability
- quality
- your design brief
- analysing products.

Context

The context refers to any aspects of the situation, circumstances, events or background environment that are relevant to where, how and by whom a product is needed and used.

Primary and secondary functions

The primary function of a product is the main thing a product does or the basic reason why the product exists. Secondary functions support the primary function.

It is often the secondary functions that differentiate products from their competitors. However, from a cost point of view, it may also be the secondary functions that are eliminated from the product's design. A good question for a secondary function might be, 'What's the point of having that there?'

Let's take a simple product such as a can opener. Its purpose or major function is to open cans. Therefore, to function as a can opener, it needs to pierce the lid and then be able to cut around the edge of the can so that the lid can be removed. Along with its major function there are many other things that need to be considered, such as safety for the user, ease of use (ergonomics), dependability, ease of cleaning, storage, etc. These are called secondary functions or sub-functions.

Shutterstock.com/terekhov igor

The primary function of a can opener is to open cans. It has many secondary functions to help with this function.

The term 'secondary functions' was defined by Lawrence Miles (USA) in 1945 in his Value Analysis approach. It was a method he developed for General Electric (GE) to improve the performance of products (mostly war equipment) and reduce waste in manufacturing during World War II.

You may be asked to define the primary and secondary functions of a product. The table below should assist you.

Examples of primary and secondary functions

Product	Primary function	Secondary functions (supporting the primary function)	
Reclining armchair	For people to sit on and relax	• Mechanism to control it reclining back like a sofa • Handle to recline chair • Solid legs to make it stable	• Ergonomics used in deciding on the height, width and other dimensions to suit users • Soft cushioning to make it comfortable
Restaurant chair	For people to sit on when eating	• Shaped to allow for stacking • Back rest to support user's back	• Ergonomics to determine height • Material chosen must be easily cleaned
Coffee table	To place things on	• Legs to make it sturdy • Rack or shelf underneath to store magazines and/or objects	• Flat, level surface to prevent spillage of liquids • Height to suit users
Carry bag	To carry things in	• Fastener (zipper, magnet, press stud, buttons, etc.) to secure belongings • Compartments or interior and exterior pockets to store smaller objects	• Handles or strap placed for easy carrying • Use of colours, specific materials and/or textures to enhance its visual appeal
Jacket	To wear and provide warmth or sun protection	• Pockets to carry things and keep hands warm • Fasteners to keep it 'done up'	• Suitable size to fit the wearer • Made of fabric suitable for purpose
Tool box	To store tools and be portable	• Light enough to carry • Strong enough not to break with weight of tools • Lid to secure contents • Hinges to open/close lid	• Compartments for sorting and protecting tools • Sturdy enough to sit on with a flat-top surface • Handles on the side to lift and carry • Hinges to allow handles to flatten
Swimwear	To wear while swimming	• Sized to fit the wearer • Choice of material to be suitable • Modest design to wear casually beyond pool	• Opaque, non-sag materials to provide modesty • Use of colours and textures to enhance visual appeal • Straps to tie around neck

This table is only a brief outline and, depending on the context, you may be able to outline many other secondary functions. Notice also that many secondary functions are parts of the product with their own specific purpose, yet all help the product to perform its primary function.

Functionality

Functionality is another way of expressing the combination of the primary and secondary functions. It is the ability of a product to do its job, or how it works, operates and performs.

functionality the ability to perform a task as required

It is how all the bits and pieces combine to make the product 'work' effectively for its intended purpose. For example, when designing and manufacturing passenger restraints for cars, the colour, texture and shape of a restraint are of little importance if it does not adequately protect the passengers. The important features for functionality are related to the ease of putting the seatbelt on, the way it sits on the body, flexibility for passenger movement, the strength of the locking mechanism when the vehicle brakes suddenly, and the method of releasing the seatbelt to get out or if in an accident.

Commercial design for safety products often has a strong emphasis on functional efficiency. A great deal of effort goes into ensuring reliability and ease of operation.

Hunter & Richards, http://interiordesignmelbourne.com/

The *Little Bishop* is a ceiling hook for cable-hung lights by Hunter and Richards Design, Melbourne. It is extremely functional, yet simple and elegant.

Reliability

Reliability refers to whether the product can be depended on to perform its function repeatedly. It should also perform over a long period of time, without failure. For some products, such as clothing, it might be about how it washes or retains its shape.

Operation and performance

Operation refers to how a product works. It relates to products with a series of physical and mechanical aspects linked to their function. Performance refers to the manner or quality of the function or operation and is often measured against a standard. For example, a well-designed can opener *performs* well if it is easy and safe to *operate*.

Quality

Quality is an important facet of function and it also overlaps with legal factors – a product must be safe for consumers to use, and quality is an important factor in safety. *Legal factors are discussed on page 108.*

A common meaning of quality is that a product is suited for its purpose, yet we often use it to imply 'good or excellent quality'.

What makes a product good quality? What is high-quality design?

For a useful product, quality can be defined as the features or characteristics that influence its ability to satisfy its stated purpose or function. Defining quality in a product depends on your knowledge and expectations of the product's function, the materials it is made of, the look you are after, and the way it is constructed or 'stays together'.

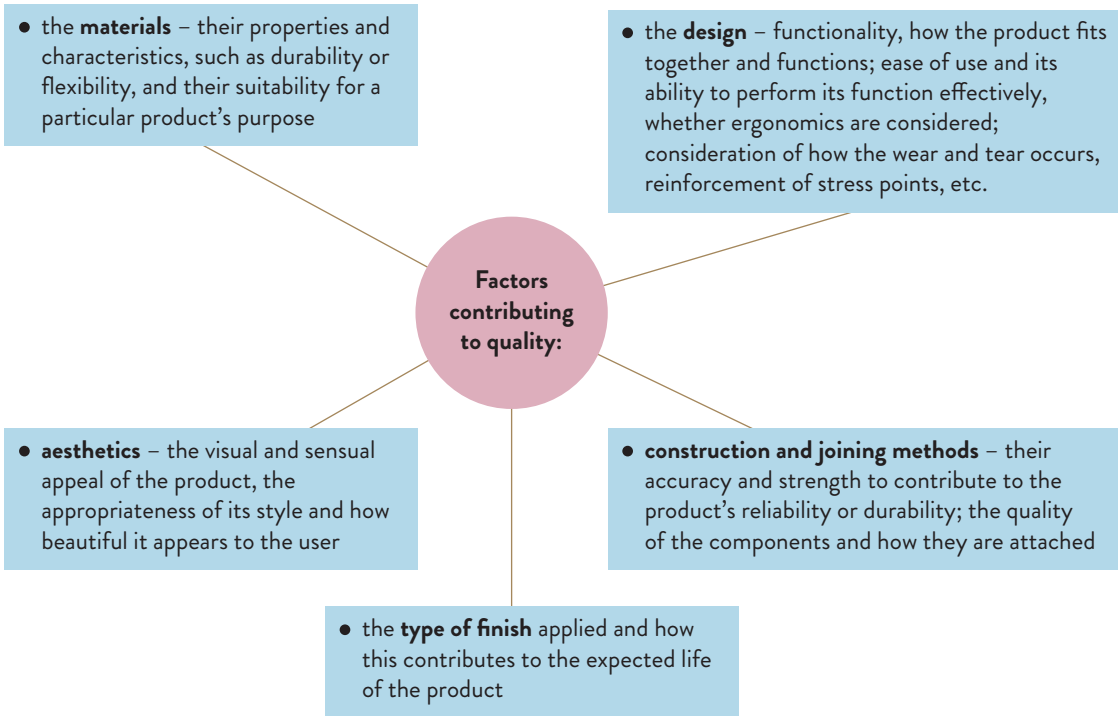
Many companies adopt Australian or International Standards for their products, which give them a set of requirements to adhere to and ensure the product meets expected standards of quality. Inherent characteristics or features of a product that contribute to quality may also set the product apart from others or denote a degree of excellence. One obvious expectation of quality is about the product's reliability, durability and strength – how long it will withstand wear and tear.

Checking quality is a constant activity for companies, as poor quality results in lost sales and a damaged reputation. Quality checking methods include having:

- a philosophy about quality and how it will be included in every phase of design and production
- a written checklist describing the quality standards expected at each production stage
- 'quality controllers', whose role it is to check specific or all aspects of the product or the process
- robots to scan products for faults
- product returns and warranty claims monitored.

Whatever the system, checking quality requires vigilance from all staff. *To find out more about Australian and international standards, go to page 112.*

The concept map below indicates areas for you to concentrate on when determining the quality of your product.



All the points in the diagram above contribute to a product's ability to continue functioning through many uses and also to be loved and cherished by the user. These are important considerations when you are looking for quality, reliability and good value in a product. Many reputable companies back up the stated quality of their products with assurances, warranties or superior service whenever there are problems. This tends to instil a feeling of confidence in the customer that the product is 'worth' paying for.

In your design brief

One of the first aspects to be defined in your design brief will be the intended purpose of the product. An important requirement will be that *the product fulfils its expected function*. The function will rely on the **context** of the design problem. The context is the circumstances, surroundings, environment, background or settings that make up the situation. For example, the context for a design problem related to seating could differ from being in an office, a lounge room, an outdoor garden or in a kindergarten. *To revise the contents of the design brief, go to page 12.*

context
the details of the situation

When writing your design brief, include requirements regarding the expected function and the expected quality of your intended product.

Aspects relevant to the function are size, weight, performance, operation, reliability, quality, safety and ergonomics. Many of these could be secondary functions. *To find out more about ergonomics, go to page 101.*

During the design process

Test out functional aspects and aim for quality with trials. Get end-user feedback. Refer back to the context to determine suitability. Create a list of quality measures and check quality in everything you do. *See Chapter 2 for suggestions for quality measures.*

When analysing products

Analysing products designed by others is an informative process that can add to the quality of your own designs. When analysing products, determine the purpose of the product to suit the context. Look for the factors that are important for effective functioning. Identify the **primary function** (or major function) and the **secondary functions** that enable the primary function to perform most effectively and suitably for its context.

primary function
the main purpose of a product

secondary functions
functional aspects that add to or enhance the primary function

USER-CENTRED DESIGN

User-centred design focuses on a select group of people, what their needs are and how they interact with products. It is also about contributing to the wellbeing of society and improving the quality of life – not just for individuals, but for everyone. It is specifically looking at a particular user need and how a product can be designed to fit that need, rather than expecting users to adapt or change their behaviour.

user-centred design
design that focuses on the user

We will look at user-centred design in relation to:

- culture and religion
- age and economic status
- emotional and sensory appeal
- inclusive or universal design
- social and physical needs
- fashion and trends
- safety, accessibility, comfort and ergonomics and anthropometric data.

Culture and religion

Cultural and religious beliefs and behaviour (often arrived at through history, ethnicity, location, the climate and economics) are contributing factors to human needs.

Many religions and cultures have rules by which people live their lives: the way they relate to one another, to other living things and to the environment. This influences their thinking, designs, architecture and use of technology. All of this affects or determines the way people behave in many contexts, which in turn determines how they use products and what their expectations of those products are.

9780170400336

Designing products

Culture and religion also need to be considered in the designs of urban areas, houses, community buildings, clothing and fashion, furniture and systems. In many cultures, there are specific rules for communication and physical contact between men and women. These cultural 'rules' must be taken into account when designing products or 'places' for such communities. This is of particular importance in human-centred design, which is a philosophy developed largely by international design company IDEO and is about appropriate design for people in the world living on less than $2 per day.

Find a link to the IDEO toolkit for human-centred design at http://nelsonpdtvce.nelsonnet.com.au.

Indigenous Australian society has specific needs, traditional customs and very different beliefs from the predominantly Europe-centric behaviour of Australians who arrived in the last 200 years. Indigenous Australians are currently some of the poorest, most marginalised and most incarcerated (jailed) people in the world, and many have very poor health outcomes. Many designed solutions have failed to cater in a holistic way for Indigenous people and have not been successful. This is due largely to a failure on the part of others to understand or take into consideration traditional beliefs and customs when trying to remedy their situation.

Religious or cultural misappropriation

Appropriation is when a person borrows or takes elements from a religion or culture, which may seem exotic or marginal, for purposes of their own that are unrelated to the original significance.

Australian Aboriginal tribes have different secret stories and rituals, songs, dance and symbols that are sacred for specific tribe members, such as women, children or young men. Traditionally artwork has been a way of passing on this knowledge about country and culture to specific tribe members, and artists are restricted in what they can depict without causing offence.

Today, art continues to be really important for Indigenous Australians; not only does it tell their stories, but it is closely linked to their employment and livelihoods. However, there are many instances where Aboriginal artwork is 'taken' and painted on cheaply made, mass-produced 'tourist artefacts' by people with no understanding of what they are painting. Unlicensed imitations of Aboriginal art on products may offend Aboriginal people, harm their livelihoods and can infringe copyright and moral rights. Ethical approaches require designers who wish to use Indigenous people's artwork to collaborate with, or seek permission from, the artists so as to avoid misappropriation.

Alamy Stock Photo/Media Services Asia Pacific

Desert Designs makes its clothing from fabric printed with designs by the late Walmajarri artist Jimmy Pike. The designs are appropriately used with permission and do not use secret or sacred images.

A link to the Osklen website is provided at http://nelsonpdtvce.nelsonnet.com.au. Click the link to see how Oskar Metsavaht of the Brazilian sportswear brand Osklen worked with the Asháninka tribe from the Amazon in 2016. The tribe will receive royalties and benefit from public awareness of illegal logging and environmental degradation. *See the case study on Christi Belcourt and Valentino in Chapter 10.*

Age

A user's age may have an impact on the way they interact with a product. When designing products, the very young and very old need special consideration as they are vulnerable and can be easily injured. Products for these age groups need to be safe and appropriate for their level of physical and mental capability.

Economic status

Designs for impoverished communities

User-centred design is extremely important in impoverished communities, where it is often known as human-centred design. If designers do not observe, listen to or research how these communities live, then their work may not be of any benefit.

Particularly important are the finances available to purchase the product, use it and maintain it. First, the people must be able to afford the product; second, it must be able to be used independently of extra financial input for parts, power or fuel; and third, it must be easy and cheap to maintain. Any design must take into consideration that many people in impoverished communities could be living on less than $1 per day, and may not have access to clean drinking water. It must also consider cultural issues, such as whether girls or women are allowed to undertake certain activities.

Many designers look to developing countries for opportunities to create clever, inexpensive designs that improve the quality of life for people with minimal resources.

OLPC, Inc. Courtesy of Fundación Zamora Terán

A classroom in Santa Clara, Nicaragua, participating in the One Laptop Per Child educational program in partnership with Fundación Zamora Terán. A hardy, inexpensive computer was designed for this purpose.

Designs for average incomes

While 15 per cent of the world's population, or more than the world, or more than one billion people, live on less than $2.50 per day, the majority of people live on $2.50 to $100 per day. Most products are aimed at this group with varying degrees of quality and affordability.

Designs for wealthier communities

At the top end of the scale are products designed without constraints around costs. While everything has a price limit, some people can afford exactly what they want and are prepared to pay for it. Think of luxury goods, transport, housing and experiences, e.g. travelling to Mars.

Think of some buildings and infrastructure in wealthy countries that benefit all members of society.

Emotional and sensory appeal

Emotion plays a huge role in guiding a consumer's purchase, and it can be both conscious and unconscious. Products can be bought because of sentiment, nostalgia, desire for status, the need to 'fit in', laziness or simply newness or novelty. Companies often market their brand to tap into these emotional responses.

Designers can tap into people's emotional needs for a product by making it appeal **viscerally**, behaviourally and reflectively. Sensory appeal is a part of this – the way a product can be seen, smelt, heard, felt and touched also affects a consumer's willingness to purchase it.

viscerally
with a deep inward feeling, rather than an intellectual one; a 'gut' reaction

As a designer, consider how people will react to your product emotionally and with their senses. *Read how important emotional appeal is to Alessi, an Italian design factory, on page 370.*

Inclusive or universal design

Inclusive design – also called 'universal design' or 'design for all' – is about designing products for use by a broad range of people, especially those who are sometimes excluded from using mainstream products because of their age, gender, ability or economic status.

inclusive design
design for everyone that considers varying needs

People are living longer, and often an increase in age brings diminished capabilities, such as strength, dexterity, eyesight, hearing and mobility. These are the important capabilities for interacting with products. Inclusive design aims to cater for both the elderly and those with disabilities. Accessibility is another term relating to consideration of those with disabilities.

Bellemo & Cat

Urban Nodes: this design for a public area in Reservoir (Melbourne) by Bellemo & Cat is an example of inclusive design as it caters for elderly pedestrians needing a rest, for shoppers wanting to chat, and has bike racks for cyclists and paving for easy access of trolleys, wheelchairs and strollers. It also promotes a feeling of community.

Aspects of products to increase the range of users could include the following:

- Visual aspects are large and bold, with different textures to indicate different parts, and use of universal symbols for controls.
- Mechanical parts can be moved easily.
- The product is lightweight and/or easy to lift.
- All parts of the product can be easily reached.
- The components are reliable.

Such approaches consider the ways people interact with products through: vision, hearing, thinking, reach and stretch, and dexterity.

9780170400336

Social and physical needs

As humans, we have a strong need to be social, to interact with others. Many products cater for this need by connecting us, allowing us to share, and providing reasons to communicate with each other.

After our basic physical needs have been met, almost every product we buy satisfies a social need, such as our desire for new clothing to wear to a party.

Some of our social and physical needs are:

- to belong
- to feel safe
- to have status
- to feel good
- to release energy
- to keep warm in winter
- to cool down in summer
- to eat well
- to keep active
- to achieve and do well
- to earn a living
- to look our best.

Fashion and trends

Fashion and trends are another aspect of user-centred design. People like to keep up with trends and this affects whether they will purchase and use a product, so designers need to produce products that appeal to a consumer's need for fashion. Fashion and trends could also be considered a social need – to be seen as being up to date, or part of the fashionable set or 'in crowd'.

Fashion and trends don't just belong to the world of clothing; they are also related to our communication products and technology, our vehicles and our houses.

Fashion forecasting has become an important tool used for planning colours, textures, materials and themes for clothing design, soft and hard furnishings, and a range of other products.

Larktale

The Australian Larktale *chit chat*™ stroller is ergonomically designed to fold and unfold in seconds, is easily manoeuvred and is extremely safe for the child and the parent, meeting AS/NZS 2088:2000.

Safety

Safety is important for any product, no matter what its purpose. It is a legal requirement in Australia that any product sold is safe for the user. However, it becomes even more important if the product is required to meet government-regulated safety standards, such as for life jackets or seatbelts or items intended for use by children.

Following ergonomic principles (*see the next section*) or complying with the relevant Australian Standard *(see page 112)* can ensure safety to the user.

Accessibility and comfort

Accessibility can refer to affordability and ease of use, but often the term is in reference to the design of products, devices, services or environments for people who experience disabilities or who are disadvantaged.

Comfort refers to how well the product fits the user or functions for them. This parameter of user-centred design is linked closely to universal design, safety, economics and ergonomic factors.

9780170400336

Ergonomics

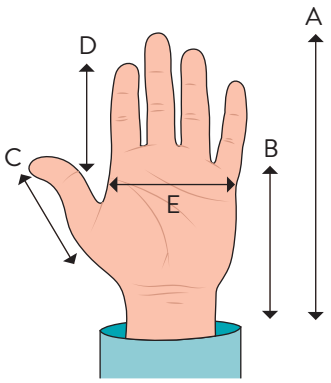
To make products physically suitable for people, ergonomic principles are applied. **Ergonomics** is the scientific study of the relationship between people and their living and working environment. That environment can include the tools, materials and equipment that are used. Designers use ergonomic principles to analyse and improve comfort and ease of use, to minimise strain and fatigue, and for safety reasons.

ergonomics the science of designing equipment and products to match the human body and the way it moves – to reduce injury, fatigue and discomfort

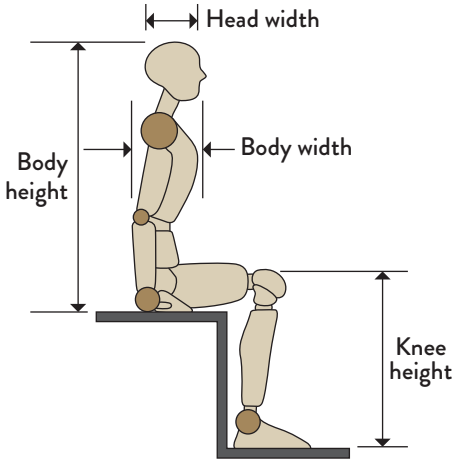
The study of ergonomics uses data from several disciplines:

- **anthropometry** – body sizes and shapes (using populations and variations)
- **biomechanics** – body movement, muscles and strength (in relation to levers and forces)
- **environmental physics** – noise, light, heat, cold, radiation, vibrations that affect body conditions, hearing, vision and sensations.
- **psychology** – perceptions, skill/experience, learning and communication that affect behaviour or contribute to errors.

Body size and shape (anthropometry)



Anthropometric data: getting average hand measurements can be important when designing handles



Important measurements (anthropometric data) for seating

All human beings have the same basic form, but we each have our own unique set of dimensions and proportions. For mass production, designers need to know the range of sizes into which most people will fall. **Anthropometric** data is used to determine these limits. This is based on scientifically collected measurements from a wide variety of people to provide us with a range of sizes for various parts of the body and the distances in between them. These sizes will be suitable for use with the majority of our population. However, some products will need to refer to data on the 5th or 95th percentile, i.e. if designing specifically for very tall or very short people.

anthropometry the measurement of human bodies

The measurements could range from the length of an index finger to the vertical reach of a person standing upright. They could be for a particular group of people, e.g. nurses or the elderly, or for a specific situation or environment, e.g. public transport or schools.

9780170400336

You can find links, including an anthropometric chart, at and useful information on anthropometry (and data) created by the UK Institute of Ergonomics and Human Factors and Allsteel (a furniture manufacturer), at http://nelsonpdtvce.nelsonnet.com.au.

In your design brief

When writing your design brief, aim to use the user-centred design approach, where you:

- consider the user and their specific needs
- define the context clearly and what is special about it, i.e. give a (brief) story about the situation and why a new solution is needed
- examine existing solutions and identify problems, i.e. aspects that don't quite perform suitably for your intended user, to include in your design brief.

During the design process

Consider how you can:

- tap into people's emotional responses to your ideas and think about how you can attract or draw them to your design
- incorporate ergonomic theory into your design and use anthropometric data to give the user less strain, fatigue or chance of injury
- focus on the specific needs of your user rather than just adapt existing solutions
- research widely to be sure you are abreast of developments or fashion and trends related to the use of your intended product; and that you understand any cultural sensitivity around the activity to be performed with your product.

When analysing products

When analysing designs by others, aim to identify the user's need and how it has been catered for in the product. Consider how deeply the designer looked into the needs of the user. Have they designed the product ergonomically? Is the product a better solution for a particular group of users than other products? Does the product appeal on an emotional level to its intended user, whether this be for prestige or for 'cuteness'?

How well do you think the product contributes to the user's wellbeing or improves their quality of life?

Cobalt Design, www.cobaltdesign.com

The *Concave* football boot by Cobalt Design is considered innovative for 'football' sports; it slightly cups and enlarges the 'sweet spot' for striking both round and oval balls on the wearer's foot. Previous boot designs focused on the foot's top ridge (only) and the sole. An earlier version of the *Concave* was patented.

INNOVATION AND CREATIVITY

Innovation is when something is new, is different to what already exists and is an improvement! Creativity is about combining different elements in unexpected ways. It can be said that innovation happens through creativity. *To revise ways of creative thinking, go to page 53.*

Innovation refers not only to products, but also to processes or organisations. It requires people to change the way they do things and the way they think, and to make choices outside their norm. Changing thinking can be as simple as changing what you expect or assume.

Innovation can be radical or tame. Radical innovation makes a notable change. It comes from inquiry, asking 'What if?' and 'Why not?' questions, and follows with experimentation.

Tame innovation is more incremental in progress, i.e. a change or modification that has occurred by small increments (amounts or steps).

Invention can also be innovative. An inventive idea usually has a creative or innovative spark that is trialled, tested and refined until something useful can be applied or developed. *For examples of Australian inventions and innovations, go to pages 342–47.*

In your design brief

When writing your design brief, be careful not to be too restrictive with your requirements to make sure you allow room for creative and/or innovative solutions. As mentioned before, make the design brief a description of the problem or need, not a description of a product. If your brief is **open-ended**, there are many methods you can use to be creative and consequently innovative.

open-ended
allowing lots of possibilities, not prescriptive

During the design process

Research widely on different fields to inform yourself. Try unusual combinations. Brainstorm and experiment with ideas for function and material uses. Explore the design elements and principles to create aesthetically pleasing designs.

When analysing products

When analysing designs by others, compare them with other designs, both current and past, to determine if and where the innovation lies. Think about the creative thinking the designer put into the design, and identify the specific aspects or features that are creative or innovative.

VISUAL, TACTILE AND AESTHETIC FACTORS

Visual, tactile and aesthetic factors are those that appeal to the senses. The visual is what can be seen, the tactile is related to texture or what can be felt (or seen) and aesthetics is concerned with beauty, style and artistic taste, not only in appearance but also in sound, smell and touch. Aesthetics are important because products we use every day affect our person and our wellbeing.

There are, however, no fixed rules on what defines beauty or makes something attractive or pleasing. Whether you find an item attractive or not can depend on a range of factors, such as your age, cultural background, peer group or the current fashion. *To revise the design elements and principles, go to page 74.*

Designers use the design principles (such as proportion, space, balance and repetition) to organise the design elements (such as shape, form, colour and texture), which are combined to create an overall image or style.

Particular materials create ‘tactile’ qualities that may attract us to a product. We want a winter jacket that will feel warm, a floor covering that will not make us slip, a swimming costume that will not irritate us when wet, a handle surface that provides good grip, or a table top that is smooth to touch. Words such as furry, shiny, smooth, rough, corrugated, pitted, silky, spongy, prickly can all be used to describe tactile qualities.

Shutterstock.com/Ivo Vitanov Velinov

Nature can inspire with its unusual shapes and colours.

9780170400336

Many designers find elements of nature to be aesthetically inspiring, e.g. the colours of autumn leaves, the spiral shape in snails and shells, the structure of flowers, animals, the textures of rocks and trees, and the patterns formed by rain or wind. Many designers also turn to geometry and mathematics when working out elegant proportions and repeating elements.

In your design brief

When constructing your design brief, be sure to include some requirements about the aesthetics that appeal to the end-user. Use the language of the design elements and principles to help you. Include any relevant tactile requirements. If the product is required to be in a particular style, then give some indication of the elements that make up that style.

During the design process

In the design and development stage, employ different design elements and principles to enhance and enliven your ideas. Use nature, geometry and mathematics to inspire and create interest or uniformity in your designs.

When analysing products

When analysing designs by others, you can deconstruct the visual and tactile factors by identifying and describing explicitly the design elements and principles. For example, 'the small, pale yellow squares repeated down the left side in a random manner create contrast with the rust-coloured front surface of the bag'.

Note that the word 'stylish' means different things to different people, so the use of this word is best avoided in your design brief.

SUSTAINABILITY

Today, sustainability emphasises the concept of the interconnectedness of environmental, economic and social dimensions. Thinking about the environment is important, but for a product or a system to be sustainable, it needs to take into account how people are affected, and it needs to make economic sense. *To find out more about sustainability, go to Chapter 5.*

The three legs of the 'sustainability stool'

Let's take a closer look at the three legs of the 'sustainability stool' – sometimes called the 'three pillars of sustainability'. They are:

- social
- environmental
- economic.

The stool analogy is useful: if one leg is removed (or one area isn't considered) the stool will fall over and sustainability won't be properly supported. All areas are interdependent.

Social aspects of sustainability

The social aspect of sustainability is about ensuring the needs of people are considered and addressed. The safety and health of all people is important, whether they are the workers, retailers, partners, designers, suppliers, consumers who use the products, or those who live near the factories or processing plants. *Read Etiko's case study on page 133 for an example of a company that supports its workers and their families in Pakistan, and the sporting development of Indigenous communities in Australia.*

9780170400336

Environmental aspects of sustainability

The environment is our air, water, land, animals and plant growth. Every product we buy consumes these resources and can impact negatively on the environment. Looking after the environment entails reducing the impacts of materials sourcing, conserving and recycling resources, reducing waste and reducing the impacts of product use and disposal. When designing and using products, we need to minimise our disruption of ecological systems both large and small.

Chapter 5 has more information on life cycle assessment (LCA), embodied water, energy and carbon.

Economic aspects of sustainability

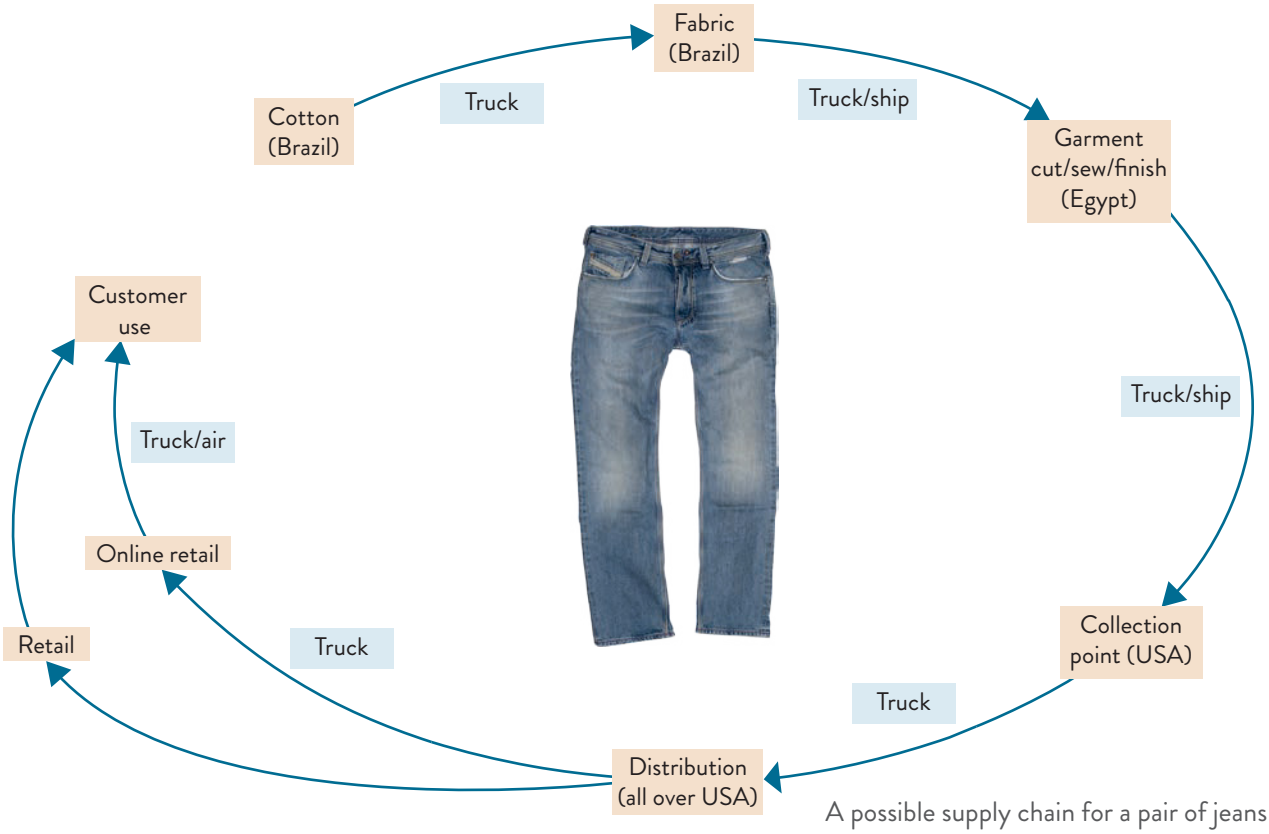
Economic growth is important for nations, companies and individuals. But to contribute to sustainability, economic growth needs to occur without negatively impacting on community wellbeing or environmental integrity. It is also important that sustainable products are profitable, so that environmental and social principles can be ongoing, supported by financial stability and growth for all involved.

Workers should be paid fairly for their efforts – you can see how this is closely connected to social sustainability, as it relates to working and living conditions.

The supply chain

Part of the creation and development of innovative, sustainable products is ensuring that their journey to market – the **supply chain** – has been ethically sound. Some companies try to distance themselves from the impacts of the products they make or distribute. They blame

supply chain the activities and people that link the conversion and movement of raw materials all the way through to the finished product



A possible supply chain for a pair of jeans

Shutterstock/OxfordSquare

9780170400336

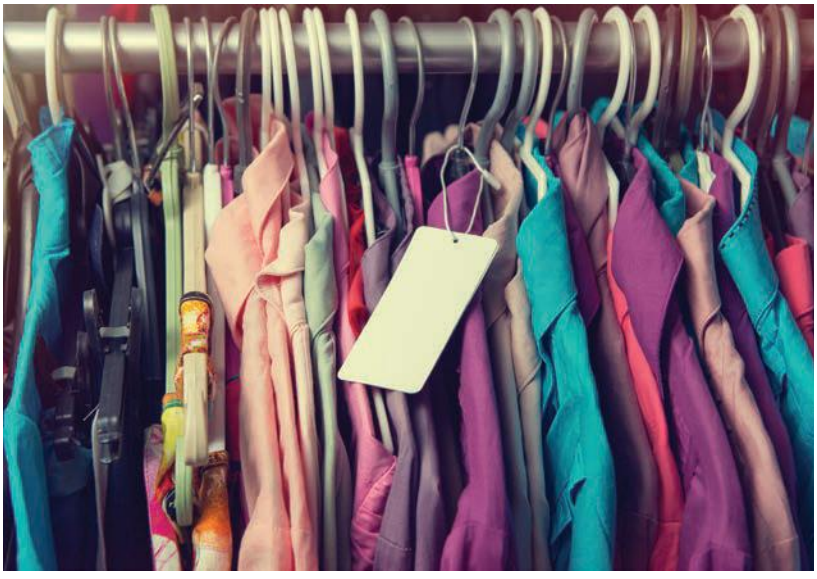
their suppliers for any problems, or plead ignorance. However, businesses have a responsibility to know the origins of raw materials; that workers in the supply chain have been fairly treated; and what impact manufacturing processes have had on the environment. Informed consumers are looking for this transparency – they want clear facts, without important information being hidden from them.

Closed loop or circular economy

Many companies voluntarily opt for a closed loop in production. This means that materials are consistently reused rather than discharged as waste. A Dutch company called Mud Jeans has a closed loop philosophy, where they collect used jeans, shred them and spin the fibre with virgin cotton to create new jeans.

Read about Mud Jeans – Circular Denim and about Closed loop efforts by Swedish brand H&M at the link provided at http://nelsonpdtvce.nelsonnet.com.au.

Read about the Circular Economy and watch an animation about the Ellen Macarthur Foundation at the same link.



Shutterstock.com/Sensay

A typical crammed closet, with some items still carrying their price tag

Emotional attachment

The emotional attachment we have to products and the act of purchasing them can have positive and negative sustainability impacts. We often get an emotional 'high' from the act of buying something new, which may lead us to purchase products we don't really need or throw away something that is still useful. Designers, manufacturers, retailers and marketers play on those emotional attachments and responses.

Despite awareness of sustainability issues – e.g. the triple bottom line of people, planet and profits – there is not often a connection between these factors and the purchase of products. We are enticed to consume beyond our daily requirements. Every country wants economic growth, yet this growth is often reliant on increasing production and comes with a cost to our planet and to ourselves. Clothing in particular has become one of the biggest polluters of our time.

Emotionally, we want and desire new things! As philosopher Alain de Botton says in his book *Status Anxiety*, we want and need to keep up with our peers and current times. And as technology develops, we are presented with the constant need for 'newness'. An astonishing number of clothes that are purchased are never worn, or worn only once. Products are often purchased spontaneously or on a whim, because of their emotional attachment: people want to feel happy, 'up to date', have their status recognised and indulge their sentiments, and because of this they buy things they don't need, don't want and don't use.

However, more and more consumers want to know that their purchasing decisions are not contributing to environmental, social and/or economic problems. They want to know all

about the quality of the product, the expected life of the product and its supply chain. They want to buy less, and hope that what they buy is of high quality and will last a long time, or can somehow be reused or recycled.

In your design brief

When writing your design brief, you could include requirements relating to sustainability (you are required to consider this in Units 1 and 2).

During the design process

Research in depth and make choices around the overall design of your product, the materials you choose to use (check the supply chain), waste minimisation, efficient production processes, quality construction methods and disposal or reuse of the materials in your product.

When analysing products

When analysing designs by others, look at the materials used, the construction methods, where it was made and how it is transported to consumers. (Many companies now have websites that give details of their entire supply chain.) You may be able to think of how a product could be more sustainable – your suggestions could be for the product itself or the way it is distributed.

Ask whether the company puts back into society by donating to research or by running community programs. Research will be required, and you will have to investigate claims made by the company. *To find out more about environmental issues go to Chapter 5.*

ECONOMICS

Costs

During the design process, designers must monitor the overall cost of a product. Aspects that contribute to costs for designers or manufacturers include:

- materials, and any parts or components
- labour – time is money!
- energy – electricity used for lighting, machines, heating and air conditioning
- facilities – the cost of the manufacturing space
- equipment – maintenance, repair and replacement
- compliance with legislation – putting measures in place to comply with legislation relating to the environment, health and safety, etc., may increase the cost of production; a company may need to install a filter system to cope with fumes, dust or noise, or comply with strict regulations for the cleaning up or disposal of particular materials; this involves time and extra labour, and contributes to the overall cost
- distribution
- marketing.

Mostly, retail price is determined by what the consumer is prepared to pay, and this is often worked out by looking at the price of similar products. The cost of designing and making a product is balanced against its expected sales. As you learned earlier, secondary functions exist to support the major function of a product and may contribute to its high quality and be the **unique selling point (USP)**. However, they may also increase the cost of production. Therefore, a company would look closely at sales data to determine whether the secondary functions were a necessary and worthwhile addition. *To revise secondary functions, go to page 92.*

unique selling point (USP) something 'special' or different about the product that is used to attract consumers

9780170400336

Time

Time is often equated with cost, as extended time in design and production means more cost for labour and energy use, and therefore less profit.

Getting a product to market at the right time is also crucial for sales. If the product is too early it may be seen as unnecessary or too expensive. If it arrives on the market too late, it may already have been beaten by competitors' products. In the competitive clothing market, the time it takes for a product to go from initial idea to shop floor has reduced significantly in the last few years.

In your design brief

When writing your design brief, you will need to include a date when the product (or prototype) needs to be finished, and a budget.

As you are designing for a school project you won't be able to factor in a cost for your labour, machinery or the facilities. Imagine if you did!

During the design process

Research the cost of materials. Create and use a timeline. Eliminate time-consuming details that will add to your cost and delay your progress. Use methods to avoid waste. Do trials on cheaper or scrap material to avoid mistakes. Find other steps to complete if waiting for material, components or your teacher. Make notes on what to do at the next session.

When analysing products

When analysing designs by others, you will not find information on the cost to design and manufacture the product, nor the imperative dates. However, you will easily be able to find the retail price and you will know the year or decade in which the product was being sold. Retail cost will be a factor that influences whether you think the product is of value, and is often used as a comparative measure with other products.

LEGAL RESPONSIBILITIES

There are many legal responsibilities associated with the design and manufacturing of products. The legal aspects relevant to this study are:

- intellectual property
- Australian and International Standards
- Occupational Health and Safety (Victoria) or Work Health and Safety (Australia).

Intellectual property

Knowledge of intellectual property (IP) is introduced in Unit 1 but it is expected that students respect and attribute the creators of ideas and designs in all units. In Unit 3 students appropriately attribute the IP of others; particularly during the research and conceptualisation stages when used as inspiration.

What is IP?

Intellectual property (IP) is the property of your mind or intellect, such as ideas, information and the many ways in which these can be expressed. Protection of IP is about the right to own, and earn from, your creations. IP is protected under the categories of copyright, designs, patents, trademarks, circuit layout rights, plant breeders' rights and confidentiality/trade secrets.

The categories most relevant to this study are copyright and designs. Patents and trademarks are also relevant, but to a lesser extent. However, acknowledging the IP of any work of others you have used is relevant to all VCE units.

Types of IP

Intellectual property categories most relevant to Product Design and Technology			
Copyright	Design	Patents	Trademarks
Free and automatic rights	Need to be applied for, entail a cost and are administered by IP Australia		
Copyright Protects the original expression of ideas, not the ideas themselves; rewards intellectual skill and effort in works such as books, films, music/sound recordings, newspapers, magazines and artistic works (painting, sculpture, drawing, engraving, photographs), one-off fashion garments and jewellery	**Design** Design registration protects the overall appearance of a functional product (not the way it works). Design refers to the features of shape, configuration, pattern or ornamentation. It must be new and distinctive from other products on the market. It protects fashion, jewellery, furniture, homewares, toys and other accessories that are to be mass-produced.	**Patents** Protect how an invention works or functions. They are for devices, substances, methods or processes that are new, inventive and useful. The types of products that can be patented are extremely varied. 'Innovation patents' are suitable for an innovative step, rather than an invention.	**Trademark** A trademark protects a letter, number, word, phrase, sound, smell, shape, logo, picture, aspect of packaging or any combination of these – i.e. branding – that is used to distinguish goods and services of one trader from those of another.
Protected for 70 years after death of creator	Protected for 5–10 years if fees are paid	Protected for 20 years, with fees payable every 5 years (8 years for an innovation patent)	Protected indefinitely if fees are paid every 10 years

Adapted from www.ipaustralia.gov.au

Copyright and designs

Once a 2D design becomes a 3D product (or an artistic work is used in 3D form) and is produced commercially (i.e. applied to more than 50 articles), it needs to be registered as a design in order to receive protection. It is then considered functional and will no longer be granted the free and extended time protection of copyright.

3D printing

Both design and copyright laws can apply to 3D printing, so users need to be aware of them and find out who created the design being printed to reduce the risk of infringement.

9780170400336

Fashion: What constitutes a design for registration?

A fashion design can be registered for its visual appearance, such as:

- a skirt with ruffles
- the cut of a shirt or dress
- an embroidered or textured surface
- a decorative 3D pattern made with studs, sequins, ribbons, etc.
- the shape of a purse
- special pocket designs on the garment.

Fashion companies may have both trademark and design protection on a product such as a bag. Patents may be granted to clothing if there is a new device added, such as temperature detecting technology or medical identification tags. They can also be granted to textiles such as fabrics treated with conductive polymers to transfer heat.

Industrial design: What constitutes a design for registration?

Industrial design or design objects are terms that refer to functional articles such as: furniture, homewares, toys, machinery or fashion accessories.

They can be registered for their visual appearance, such as:

- a pattern woven into carpet
- a chair with unusual legs or back support
- the arrangements of shelves and compartments inside a fridge
- the shape of the body, spout and handle of a kettle.

www.caphat.com.au

The *CapHat*® sun protection by Bernie Sharrad is protected by a trademark, a patent and design registration.

Stephen Ziguras, Eco wood designs

Stephen Ziguras is the owner and designer at Eco wood designs. He makes furniture, homewares and wooden objects to order. He has registered IP (design, trademark and copyright) to protect his unique products.

Examples of patents

Patents can be granted for products such as bicycle helmets, garage doors, wheelchairs and air conditioners. Some recent Australian patents have been in the surf industry for products such as fin plugs, foot strap systems, removable and adjustable surf fin systems, a storage compartment within a surfboard, heated wetsuits and surfing sunglasses.

The patent itself is a document containing technical drawings, measurements and written descriptions – it covers the scientific and/or technical knowledge contained in its descriptions.

Multiple registrations

It is possible that one product may require several forms of protection.

Protecting your own IP

Protecting one's IP gives the owner the right to:

- exploit (use, license or sell) their creation for a given time
- prevent its use by others.

If you want to commercialise your 'creation', it is important to seek legal advice so as to get the best protection against your design being copied or misused. You are also responsible for monitoring the market to check for infringements.

If using another's IP, you must seek permission. Legal action can be taken against those who infringe (see below). Note that the creator is not necessarily the IP owner: the creator may be working under contract, in which case the contract will state who owns the IP.

What is IP infringement?

Using another's intellectual property commercially in the way reserved for the IP owner, i.e. copying and selling it, without permission or acknowledgement is considered an infringement and is against the law. For example, you could not use the Nike 'swoosh' on your own products and sell them commercially. If you were discovered to be doing so, you could be issued a warning letter; a request for a licensing arrangement (granting permission, usually with associated fees) or an out-of-court settlement (i.e. money); or court action.

Moral rights

Copyright Amendment (Moral Rights) Act 2000

The individual creator of a work has moral rights. They may not own the IP (due to the work being created while an employee, contractual obligations or on-selling of their IP) but they have non-economic rights.

These include the right:

- to be attributed as the creator of the work in a clear and reasonably prominent way so that it is obvious to the viewer
- not to have work falsely attributed (i.e. attributed to another, or altered and be attributed as unaltered)
- to take action if their work is treated in a derogatory way (i.e. mutilated, distorted or displayed in a context that affects their reputation).

Moral rights: Attributing others' work in your folio

When using images of work created by others in your folio, you must observe their moral rights by displaying their name in a clear way so that it is obvious to the viewer. As a student, you are entitled to use others' IP for educational purposes, but you must still acknowledge them. However, if you are displaying your work in public in a commercial way, you do not have the same allowance and must seek permission. (Schools pay fees for licences to use copyright works in the course of educational instruction.)

Copyright in your folio

Copyright means what it sounds like – the right to copy, which belongs to the owner of the copyright. When writing text, students must clearly distinguish between their words and those of others. This can be done by several methods, such as:

- the use of quotation marks
- a different font, with the source in brackets
- indentation, with numbering (citation) that refers to a bibliography
- the URL of digital sources with a date of access directly underneath.

It is a requirement that all unacknowledged work is your own. Therefore, it is important that you clearly indicate the work of others. It is not expected that you reference faultlessly, but you are expected to acknowledge the source of any informative work and differentiate it from the development of your own ideas.

Alternatively – do your own work whenever possible. Take your own photographs, create your own patterns and be inspired from unrelated areas to develop your own ideas.

Links to the IP Australia website and the Australian Copyright Council are provided at http://nelsonpdtvce.nelsonnet.com.au.

A link to the Australian Copyright Council's information sheets is also provided at http://nelsonpdtvce.nelsonnet.com.au. Look down the list for Sewing and Knitting Patterns (G039), Fashion and Costume Designers (G076), Design Objects and Copyright (G027), 3D Printing and Copyright (G128) and Moral Rights (G043).

Australian and International Standards

What is a standard?

standards
technical specifications

Standards are documents that set out technical specifications or other criteria necessary to ensure that a product, service or system will consistently do the job it is intended to. Their purpose is to ensure *safety*, *reliability*, *consistency* and *quality*. They are living, changing documents that reflect progress in science, technology and systems.

Australia has close to 7000 standards and, wherever possible, they mirror International Standards. The International Organization for Standardization (ISO) is responsible for developing worldwide standards.

International Standards ensure products manufactured in one country can be sold and used in another. Standards reduce technical barriers to international trade, increase the size of potential markets and position Australian firms to compete in the world economy.

Australia and New Zealand have common standards, hence you will see many standards with the prefix 'AS/NZS', a number and the year.

Note that not all products have standards, and that most standards are adopted voluntarily.

Mandatory standards

mandatory
required by law

Some products, however, have **mandatory** standards. Many of these relate to products for children, including:

- a wide range of children's toys (AS/NZS 8124.1: 2016)
- bunk beds (AS/NZS 4220: 2010)
- cots (AS/NZS 2172: 2013)
- beanbags (Safety standard 2014).

A standard becomes mandatory when the government identifies it or refers to it in legislation.

9780170400336

Find out more about mandatory standards, and about safety with beanbags in particular, at the government website Product Safety Australia. Link directly to this website via http://nelsonpdtvce.nelsonnet.com.au.

International Standards

Many International Standards relate to how a product is produced, rather than to the product itself – they outline management systems such as Quality Management Systems (ISO 9000) and Environmental Management Systems (ISO 14001). They are generalised and can be applied to all companies, whether they are making cheese or supplying counselling services (for example). ISO does not certify products; each country has its own organisation to do this.

Health and safety (OH&S or WHS)

OH&S or WHS (respectively, Occupational Health and Safety and Work Health and Safety) applies to all workplaces – they must be kept safe for employees, customers and the general public. Workplace illness and injury can cost a business a great deal, both financially and in reputation.

All businesses in Australia are legally obliged to provide:

- safe premises
- safe machinery and materials.

In Victoria the *Occupational Health and Safety Regulations 2007* (made under the *Occupational Health and Safety Act 2004*) specify details to support the Act (e.g. requiring licences for specific activities, keeping records or notifying certain matters). The regulations are closely aligned with the *Work Health and Safety (WHS) Act 2016*, published by Safe Work Australia, which aims to harmonise safety regulations across Australia. Safety regulations are often changed, so it is best to check the relevant websites for updates.

Look at the websites of Safe Work Australia, Australian Government Business and Work Safe Victoria to find out more about OH&S regulations. Links to these websites have been provided at http://nelsonpdtvce.nelsonnet.com.au.

In your design brief

Check whether there is an Australian Standard that is relevant for your intended product. If your intended product is regulated by a mandatory standard, then you will need to obtain the standard to find out the requirements. Examples are bunk beds, beanbags, basketball rings, cots, nightwear for children, and toys. Standards can be very expensive, so you may only need to purchase relevant parts, or your school could buy these as a resource.

During the design process

Attribute IP of any 'work' to its creator in your folio pages by making their name clear and obvious.

When designing your product, think about the safety of the end-user (e.g. in terms of protruding sharp edges, and the way it is to be constructed for reliability) and consider that your product may be used in an unintended way. *To revise risk management, go to pages 39–43.*

During production, be sure to follow OH&S (or WHS) guidelines. Plan for safe production by doing a risk assessment of the environment, for handling materials and chemicals, and using machinery, and consider modifications to ensure that your finished product is safe for users.

When analysing products

When analysing designs by others, acknowledge the IP (attribute the creator), check if there is a relevant standard and research its number, and determine what aspects of the product contribute to its safety.

MATERIALS

Characteristics and properties of materials

characteristics and properties
the physical and chemical structure of a material; how it looks, feels and behaves under different conditions

When making decisions about materials, it is important to consider how the **characteristics and properties** will suit the design situation. You will find many different definitions of 'characteristics' and 'properties' in different texts, depending on the field.

They can loosely be defined in this way:

- **properties** – performance and behaviour both chemically and physically (or mechanically) under certain conditions
- **characteristics** – visible features, something typical or special of that material.

However, there is so much overlap that in this text, and for the purposes of VCE Product Design and Technology, we will group them together.

Cool Clutch™ www.coolclutch.net

Cool Clutch is a fashionable bag that keeps contents cool. It has a polyester lining and a removable insulated cooler pocket (patented), which has waterproof aluminium foil lining with press studs – the material to suit the job.

Characteristics and properties can be defined by such words as strength, durability, hardness, thermal resistance, insulation/conductivity, odour, taste, feel, rigidity, elasticity, shine, density, colour, permeability, impermeability, corrosiveness and hundreds of others. *Refer to Chapters 6, 7 and 8 for more detailed information about material characteristics and properties and definitions.*

Shutterstock.com/Mountain Light Studios

Shutterstock.com/Scanrail1

The material (wood or aluminium) used for a stepladder will depend on the end-user and the context.

Suitability of materials

When selecting materials, use the critical thinking technique of asking questions. Ask what is required of the product's materials (related to the product function and form, the user's needs and the context) as well as how to cut, manipulate, form or process the material to suit.

Some examples:

- What are the strength requirements? Is the material flexible? Can it be shaped or bent? Does it return to its original shape or dimension? Does the material need to be rustproof? Will it scratch or dent easily?
- Are there special conditions under which the materials must perform (outdoors, rough treatment, underwater, heat, humidity, etc.)?

- Does the design require tolerances for material movements? Will expansion/contraction limit the performance of the material?

  Other aspects listed below are also important for any materials-related decision:
- cost of the material – 'Is it affordable?'
- environmental impact of the sourcing, production, use and disposal of the material
- aesthetic qualities of the material – 'How do I want it to look?'
- ability of the material to be processed – 'Can I work with it?'
- availability of the material – 'Can I get it?'

Aesthetics of materials

Materials are not only chosen for cost and function; they are also selected for visual appeal. Materials have certain qualities that contribute to the 'look' or style of a product, such as:

- colour and colour variation
- texture and 'feel'
- level of sheen and ability to reflect light
- markings or figure
- **transparency**, **translucency** or **opacity**.

transparent
allows light through, can be seen through

translucent
allows some light through but detail cannot be seen clearly

opaque
does not allow light through, cannot be seen through

Compatibility of materials

The compatibility of materials can relate to appearance or aesthetics, joining methods or the materials' proximity.

The dictionary meaning of 'compatible' is: 'things that can exist in the same place and at the same time without harming each other'. This is something to consider when using more than one material in a product. Mixing or combining materials can add aesthetic value and, in some situations, reduce the cost of a product. However, if the materials are not compatible, the viability of the product may be compromised.

When joining different materials, a designer must ensure that the join is strong and durable.

Proximity of materials and compatibility

Compatibility of 'touching' materials means that neither material should deteriorate because they are very close to each other. One example of this might be where fabric rubs up against brick. Dust and particles from the brick would settle on the fabric and contribute to the wear and tear of the fabric.

Iron 'touching' wood can result in rusty stains on the wood.

Other situations in which materials 'touch' each other include:

- Ferrous (iron-based) metals in close proximity to wood can put rusty stains on the wood.
- Wire can push holes in fabric when put under pressure, such as in a mattress.
- Tent frames make contact with the fabric in all weather conditions and must not cause damage.

9780170400336

Combining materials on the basis of aesthetic or cost factors must also take into account their compatibility; and this requires research. *Refer to pages 144–47 in Chapter 6 for definitions of different properties of resistant materials and pages 147–51 for non-resistant materials. Refer to the materials tests in Chapter 6 for examples of various tests that can be performed on materials to compare how they respond in different situations.* Most of these tests are designed to test materials individually; they can be adapted to test pairs of materials.

In your design brief

When constructing your design brief, you need to include some requirements about materials; however, try not to define specific materials. It is better to describe the properties and/or characteristics required so that you have some choice when purchasing materials.

During the design process

Research the materials through both primary and secondary sources. Primary – do your own tests and trials. Try out new and unexpected ways of using materials. Secondary – find proven information on materials. When combining materials, be sure to check their compatibility for joining, washing and aesthetics.

Analysing products

When analysing designs by others, aim to identify the materials, why they have been used and how suitable they are.

TECHNOLOGIES

When we refer to technologies in this study, we are mostly referring to hand-held and power tools and complex fixed machinery used in the conversion of raw material, and the processes used during production.

Conversion techniques

conversion techniques turning raw materials into useable forms

Conversion techniques are the processes required to convert raw materials into useable materials. There are many levels of useability. For example, a trunk or branch of a tree can be used as it is for basic furniture or construction, it can be rough-sawn for a more sophisticated work, it can be DAR (dressed all round) for more refined use, and it can be cut to size and finished for other projects. Manufactured board is made from waste wood and sawdust combined with glues and cut into sheets for use. It is made in varying thicknesses and some is treated for moisture resistance. Some manufactured board is veneered with more rare or precious timbers for a quality aesthetic appearance.

Textile fibres come from a huge variety of sources and substances, and although most are spun into fibre there is a myriad of conversion techniques before that.

A link to the Materia website has been provided at http://nelsonpdtvce.nelsonnet.com.au for examples of ways materials can be converted into new material products that are functionally and aesthetically innovative.

Metals are usually extracted from the ground and the methods used also vary greatly. Some are simple, but some require a lot of energy and create toxic waste.

Plastics, like fibres, come from a huge variety of sources and substances, and require a lot of processing to be made useable. *For information about the conversion techniques of different materials, go to pages 161–62 for timber; pages 181–82 for metal; pages 195–96 for plastic; and page 217 for textiles.*

Forms of material

After it has been converted for use, material is produced in a variety of forms (some more refined than others). Designers and manufacturers purchase the material in a form that is most suitable for them, e.g.:

- plastics – sheets, rods, pellets liquids, mouldings
- metal – sheets, rods, bars, tubes
- wood – rough-sawn, dressed all round (DAR), manufactured boards, mouldings
- fibre – yarn, woven or knitted fabric.

Purchasing your material

When purchasing your material, be sure to purchase it in the form that is best suited to your situation, your design brief, your workshop and your own experience. While some more refined forms of the material may be more expensive, it may be worth the cost if it avoids errors, saves time and improves the quality. For example, instead of carrying out a complicated dyeing process on a fabric, consider buying pre-dyed fabric that is similar to your needs.

Shutterstock.com/bioraven

Purchase your material in the form that is most suitable for you, e.g. plastic tubing

Choosing the best tools for the job

When designing and planning your product, you can choose from a wide range of production processes that apply technologies (tools, equipment, machinery and digital technologies). Many of these are explained in later chapters of this book, or you can search online for tutorials and videos. *Go to Chapter 7 for more information on processes relevant to resistant materials (wood, metal and plastics). Go to Chapter 8 for more information on non-resistant material (textiles) processes.*

A factor of major importance is being realistic in what you can accomplish with the resources at hand, your time and your budget. You may have to plan for someone to complete a process outside the classroom (outsourcing). This will usually involve a cost, and you will need to weigh up that cost against the benefit of getting the process completed accurately and quickly.

If you are making a prototype of a product that could be made commercially, you may not have access to the production technologies used in industry. You will need to identify the machinery and processes that give you the most similar results.

9780170400336

In your design brief

When constructing your design brief, consider the available technologies (tools, equipment and machinery) in your workshop, the scope of your intended product and what you expect to achieve. Listing the technologies is not required in your design brief, but could be considered an 'unspoken aspect'.

During the design process

Research your materials – find out the raw form, how it has been converted for use, and what processing techniques are required. Research related sustainability issues.

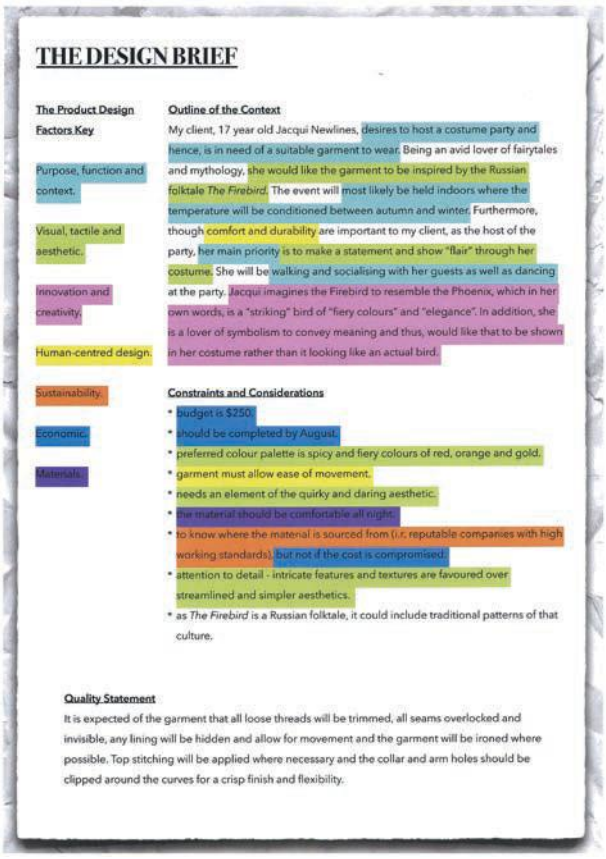
Use the basic processes listed as parameters of the technologies factor on page 91 to create a sequence of production steps, including the technology you will use to process them. Safety must be given priority in your decisions – make sure you consider equipment that you can operate safely and competently, and complete a risk assessment.

Some technologies may need to be **outsourced**, and this should be clearly documented in both your planning, safety and record of progress documents.

outsourced performed by a skilled person (or people) from outside a business, who is usually paid to do so

Analysing products

When analysing designs by others, compare the technology used with what you have available in your workshop. How is mass production of this product achieved? How is a consistent, accurate, quality product made? What could be applied to your product if it went into mass production?



THE DESIGN BRIEF

The Product Design Factors Key

Purpose, function and context.

Visual, tactile and aesthetic.

Innovation and creativity.

Human-centred design.

Sustainability.

Economic.

Materials.

Outline of the Context

My client, 17 year old Jacqui Newlines, desires to host a costume party and hence, is in need of a suitable garment to wear. Being an avid lover of fairytales and mythology, she would like the garment to be inspired by the Russian folktale *The Firebird*. The event will most likely be held indoors where the temperature will be conditioned between autumn and winter. Furthermore, though comfort and durability are important to my client, as the host of the party, her main priority is to make a statement and show "flair" through her costume. She will be walking and socialising with her guests as well as dancing at the party. Jacqui imagines the Firebird to resemble the Phoenix, which in her own words, is a "striking" bird of "fiery colours" and "elegance". In addition, she is a lover of symbolism to convey meaning and thus, would like that to be shown in her costume rather than it looking like an actual bird.

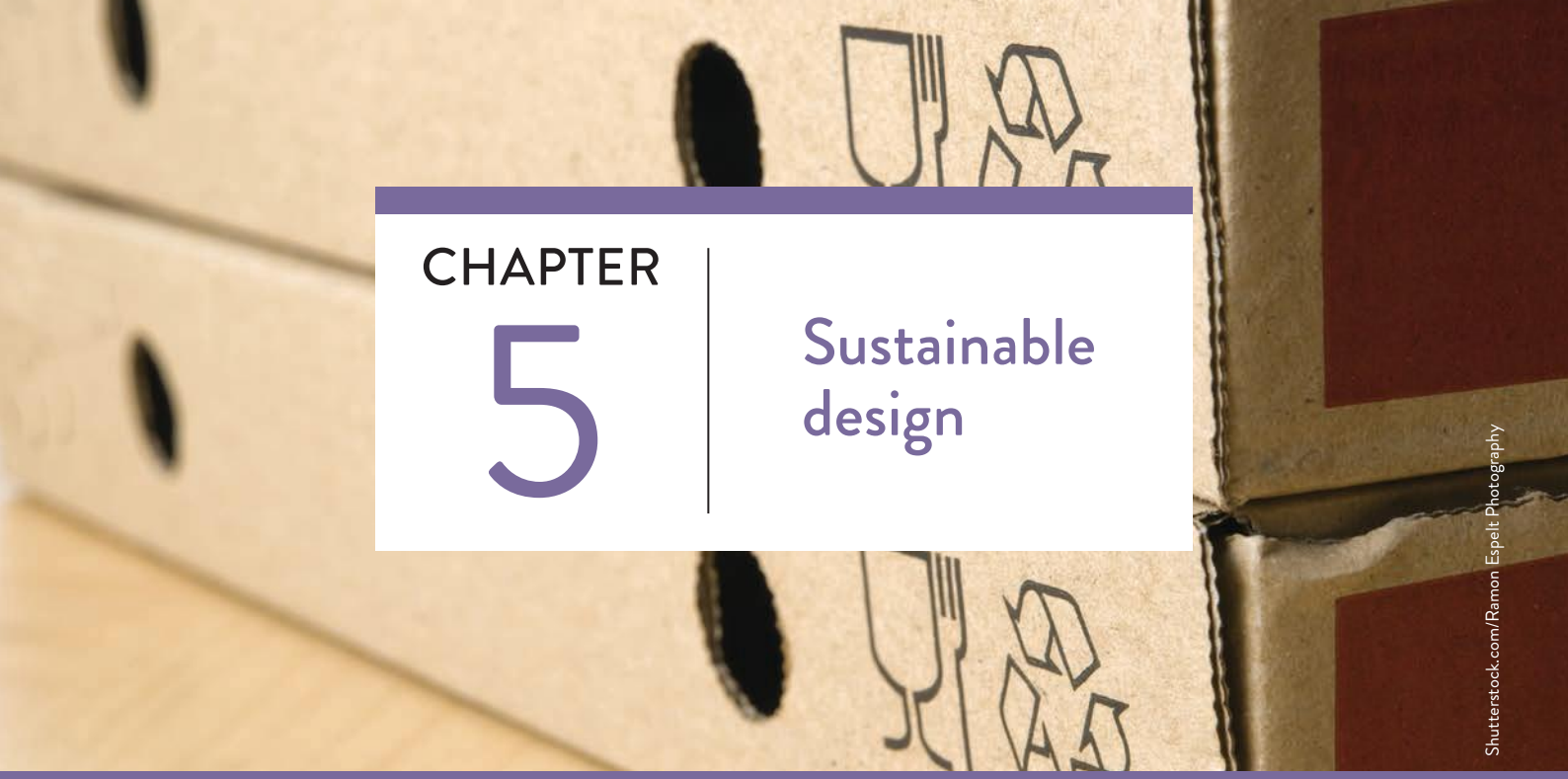
Constraints and Considerations

- budget is $250.
- should be completed by August.
- preferred colour palette is spicy and fiery colours of red, orange and gold.
- garment must allow ease of movement.
- needs an element of the quirky and daring aesthetic.
- the material should be comfortable all night.
- to know where the material is sourced from (i.e. reputable companies with high working standards), but not if the cost is compromised.
- attention to detail - intricate features and textures are favoured over streamlined and simpler aesthetics.
- as *The Firebird* is a Russian folktale, it could include traditional patterns of that culture.

Quality Statement

It is expected of the garment that all loose threads will be trimmed, all seams overlocked and invisible, any lining will be hidden and allow for movement and the garment will be ironed where possible. Top stitching will be applied where necessary and the collar and arm holes should be clipped around the curves for a crisp finish and flexibility.

Design brief by student Lian Wilson with a key to the highlighted (and relevant) product design factors.



CHAPTER 5 Sustainable design

Shutterstock.com/Ramon Espelt Photography

CHAPTER FOCUS

In this chapter you will learn about:

- Sustainability – concepts, models and major issues p. 119
- Environmental impacts – including the stages of a product's life, environmental design strategies, life cycle assessment, other environmental design approaches, and international sustainability regulations and guidelines p. 121

Through three case studies (from p. 131), you will also discover how designers and manufacturers practise sustainable design.

SUSTAINABILITY

What is sustainability? In 1987, the Brundtland Report (*Our Common Futures*) to the United Nations defined sustainable development as

> development ... that meets the needs of the present without compromising the ability of future generations to meet their own needs

and says,

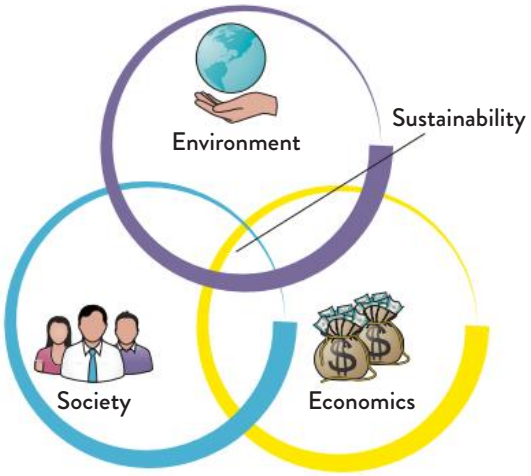
> Only 'sustainable' development could blend the fulfilment of human needs with the protection of air, soil, water and all forms of life.

This report led to the first Earth Summit in Rio de Janeiro in 1992, to the development of Agenda 21 and to the formulation of the 2030 Agenda for Sustainable Development, a comprehensive approach for global, national and local organisations that includes 17 Sustainable Development Goals.

Find a link to the Sustainable Development Goals at http://nelsonpdtvce.nelsonnet.com.au.

Different phrases and terms are used to describe this sustainable focus in all forms of development. All involve the careful balancing of the 'three pillars of sustainability' – environmental, social and economic. When considering these aspects in any decision making or analysis, the three pillars should be seen as interrelated and supporting each other; no single pillar should be viewed in isolation, or as more important than another.

9780170400336



A sustainability Venn diagram

To develop a sustainably designed product, you should:

- minimise **environmental/ecological impacts** – on land, air and sea, on all living creatures and on natural systems
- consider **social and ethical impacts** – on the health, welfare, education, law and justice, and social relationships of all people affected
- consider **economic impacts** – balancing costs and benefits, financial stability and longevity, ethics, fair pay and workers' rights.

Refer to pages 104–107 for an outline of sustainability as a product design factor.

Global issues

Why is it important to think about sustainability? What are the issues that mean we should rethink traditional ways of designing, making and consuming?

There are many pressing global problems that need to be addressed by our current generation, otherwise we will permanently damage our environment, lose many species of animals and plants, and experience extreme weather conditions that cause food and water shortages. This, in the long term, will result in population movement and international instability. Some of these impacts are already being felt by those living on the margins – on the edges of deserts and the sea.

Global pressures and problems include:

- climate change
- loss of biodiversity
- population growth – causing pressure on food production, water and land use, and increased demand for resources.

The following issues more directly influence how products are designed and developed.

Shutterstock.com/szefei

Rainforests are complex ecosystems that provide a rich source of biodiversity; many plant and animal species are lost when large areas of rainforest are cleared

Use of finite resources

A **finite resource** is one that doesn't replace itself (i.e. it is non-renewable), or replaces itself much more slowly than it is consumed. That means there is only a certain amount of this resource occurring naturally that is available for use. This presents a problem when our living patterns depend on resources that will run out.

Fossil fuels, such as oil and natural gas, are a non-renewable resource that is being used at an increasing rate due to the mechanisation of many processes and services, and the demands of a rapidly growing population. Emphasis is now being placed on the use of alternative, renewable energy sources for power and transport. Mineral resources are also finite and are mined for power generation (coal and uranium), to create metal for products, and for food production.

finite resources
non-renewable resources that have a definite limit to the amount available for use

fossil fuels
non-renewable fuels – coal, oil and natural gas; these are carbon-containing compounds, formed over millions of years, that release greenhouse gases when burned

Landfill

Landfill describes all of the space that is taken up with the waste we create. The waste we produce is usually put in large dumps or rubbish tips. These sites, once they are filled, are difficult to use for other purposes because they are usually contaminated and structurally unstable. Unfortunately, many recyclable materials end up in landfill.

Landfill is a growing problem – as the population increases, the amount of waste produced also grows and less land becomes available for storing waste. Recycling, hazardous waste separation and programs aimed at reusing and recycling materials from electronic, appliance and automotive products are worthwhile, but only slightly mitigate the problem.

Issues related to landfill include:

- the use of space or land that could be used for other purposes, such as housing and agriculture
- hazardous materials that contaminate the surrounding areas, particularly through affected groundwater seeping into the **water table**
- the high possibility of fires both on the surface and deep seated
- the build-up of gas, particularly methane gas, as the waste breaks down
- an increase in the amount of rubbish that escapes collection systems and ends up in the sea (e.g. the Great Pacific Garbage Patch or Gyre).

water table
permanent water below ground

Problems related to landfill can be affected by poor product design and overconsumption of products and packaging that are used briefly and easily discarded.

ENVIRONMENTAL IMPACTS

Much of the focus in the area of sustainability is on the environment, as we recognise that our actions have a lasting impact on ecological systems, and on the ability of the natural environment to recover and continue supporting us. Designers are becoming more aware of their responsibility, realising that the products they design use resources, contribute to pollution, and increase landfill. Many understand that they need to reduce the **environmental impact** of the products and systems they design. Such designers embed environmental considerations as a fundamental part of their decision-making process. Governments and international bodies also recognise the need for regulation to protect against the most harmful effects of product manufacture, use and disposal.

A link to Cobalt Design's approach to environmental sustainability is provided on http://nelsonpdtvce.nelsonnet.com.au. Click on 'design thinking' and read through the company's sustainability strategies or go to their staff's 'Less by design' blog site.

environmental impact
the effect of something on the natural environment – water, air quality, land, animal, plant and marine life

9780170400336

The stages of a product's life

To properly assess the impact of a product on the environment, all of the stages of the product's life need to be considered. The main stages and possible consequences are set out below.

Stage of a product's life	Description	Possible impacts
Material sourcing and processing	Mining, logging or growing materials, then converting the raw materials into forms that can be used for manufacturing Processing can involve: • growing and harvesting plant material (fibres, wood) • mining, melting and purifying metal • cleaning, spinning and creating fabric • logging, sawing, drying and dressing timber • purifying, heating and combining chemicals These forms of processing may produce toxic or polluting waste	• May cause the degradation of land and impact on indigenous people, animals and plants; use of energy and water (finite resources); the use of toxic herbicides and pesticides; and the production of pollution • May have significant ethical implications and social and health impacts on communities that live where the materials are sourced and processed, and on the workers that source and process the materials • Land degradation may affect the future economy of the area
Product manufacture	Making the products (including components that might be used in production)	• Involves using materials, energy and water (finite resources); producing pollution; and the use and possible degradation of land for manufacturing • May have social/health impacts on the workers and surrounding communities
Transport (all stages)	Moving materials/products: • from their source to where they are processed • then to the site of production • then to distribution centres and retailing locations • then to where the products are used • finally to where they are disposed of	• Involves the use of fuel (impacts of sourcing and refining finite resources) and the creation and maintenance of vehicles and infrastructure for transportation • Creates significant pollution (particularly greenhouse gases)
Product use	Products function in different ways – e.g. some use energy and fuel, others are more static, but need to be maintained or washed regularly. In the case of synthetic clothing, during the washing process, millions of tiny microfibres are discarded and end up in waste water systems and eventually the ocean.	• Involves the use of energy, fuel, cleaning/maintenance materials and/or water to make the product function or to keep it in useable condition • May produce pollution while being used or maintained, or through discarding disposable parts • The use of a product may change patterns of behaviour, resulting in social and health impacts.

Stage of a product's life	Description	Possible impacts
Product disposal	At the end of the product's useful life, it is thrown away, disposed of or recycled or repurposed. Relevant factors include: • Can the material(s) the product has been made from be recycled? • If the materials can't be recycled, how much landfill will they take up? How toxic are they as they break down? How long do they take to break down?	• Product disposal creates waste, and impacts may involve the production of pollution; increased landfill; impacts on the health of people, animals and plants in areas around landfill • Materials may be recyclable for use in other products

Impacts differ depending on the product

The level of environmental impact differs at each stage, depending on the type of product being made. For example, a pair of jeans has negative impact when the cotton they are made of is grown, cleaned and processed (large amounts of pesticides are used in the production of cotton). However, the greatest environmental impact of a pair of jeans is commonly during its 'use' stage due to repeated washing, and the amount of energy, water and detergents this uses. The level of impact also depends on whether the jeans are washed in hot or cold water, as hot water greatly increases the amount of energy required, and whether they are line dried or machine dried. Another problem is the ever-increasing quantities of jeans consumed and discarded.

On the other hand, the environmental impact of a piece of furniture is more evenly shared between the materials sourcing, production, transportation and disposal stages (although this varies significantly depending on the individual materials used; how they are processed; the distances travelled between sourcing, processing, production, retail and use; how long the piece of furniture lasts for; and whether any of the materials can be recycled). Very few of the environmental impacts of a chair occur during its 'use' stage.

The length of a product's life also has an effect on the product's environmental impacts and where they are felt most. For products that have a short life (i.e. that need to be replaced frequently), the negative environmental impact of the materials sourcing and the product's disposal stages are usually more significant than the impacts of the product's use. On the other hand, if a product lasts a long time (such as a vehicle or an electrical appliance) and uses fuel or energy when used, it may impact on the environment more during its 'product use' stage than during its materials processing, production and disposal stages.

Life cycle analysis/assessment

Making accurate judgements about the various impacts of a product is complex – it is difficult for designers to find measurable information about environmental impacts that can be used to compare and improve designs. Designers need some way of balancing the relative significance of different impacts during the product's life, so that sound design judgements can be made.

A **life cycle analysis or assessment (LCA)** is a very structured and scientific way of assessing the impact of a product and comparing it with other products made for the same purpose. Detailed research is carried out on all stages of a product's life – the materials sourcing and processing, production processes and systems, transportation, product use and disposal. It accurately measures the **inputs** (materials, energy, fuel, water, etc.) and **outputs** (pollution,

life cycle analysis or assessment (LCA)
an assessment of all the outputs and inputs in a product's life, from raw materials to its disposal

inputs
the raw materials and energy that are used at each stage of a product's life

outputs
all of the things that come out of the product's life cycle; the wastes and emissions into the air, water and soil

9780170400336

greenhouse gases, etc.) at each stage. Some LCAs also include an analysis of related human behaviour in their 'goal and scope' (see below) – e.g. how we interact with and use the product, or how we perform the activity – to look at the repercussions of how products are used and to form comparisons. For example, drying hands in public bathrooms might include a study of how much paper towel is used or how long people use the electric hand-dryer for.

A LCA report needs to include four components:

1 the goal and scope – defining the purpose of the study; deciding on the type of information needed, how detailed it should be and how it should be organised; deciding on the breadth of the study and its guiding rules
2 life cycle inventory – calculating all of the inputs and outputs
3 life cycle impact assessment – applying a weighting to each input and output according to their level of impact on the environment
4 an interpretation of the data – testing and validating the results, and drawing some conclusions.

The information used during an LCA is very complex and difficult to source and interpret, and the results are very technical. It is researched and interpreted by an environmental scientist. The process is also expensive and is usually only applied to products that are produced in large numbers by companies that can afford this form of assessment.

Other environmental design strategies

Many designers and manufacturing companies recognise the need to reduce the impacts of the products they design and make. Indirectly, consumers and governments put pressure on companies, and reinforce positive environmental change to product design. There are a number of terms that indicate a similar environmental approach to design. **Life cycle thinking** considers the impacts and looks at implementing strategies to minimise any impacts through all stages of a product's life (materials sourcing, manufacture, transportation, use and disposal). Designers who use an **eco-design** approach implement specific strategies that minimise environmental impacts.

Common to all of these approaches are practical strategies for design and production, including:

- sourcing sustainable materials that have minimal environmental impact
- ensuring that none of the materials are toxic, or create toxic by-products
- reducing the amount of material used in the product, without lessening its ability to function (de-materialising)
- reducing the transportation distances as much as possible (e.g. using locally sourced and processed materials, retailing locally, etc.)
- reducing waste in any form (materials, energy, pollution and by-products, etc.)
- designing for disassembly (DfD; to be taken apart easily) by:
  - simplifying and reducing the number of materials used in a product
  - enabling the materials to be separated easily at the end of the product's life for recycling
  - labelling materials (especially plastics) for ease of recycling
- extending the product's life by:
  - increasing durability
  - enabling the product to be serviced and repaired easily
  - enabling broken or worn parts to be replaced easily
- increasing the efficiency of the product, so that it doesn't use as much energy to operate
- ensuring that the materials from which the product is made are obtained from environmentally, ethically and socially responsible sources
- developing systems/schemes for the reuse and recycling of parts and materials.

Strategies for fabric and fashion

Environmental design strategies for fabric and fashion include:

- **clothing design** – developing clothing that is durable, classic in styling (i.e. it will not go out of fashion quickly), designed to be functional (e.g. comfortable, all parts have a purpose, limited ornamentation), multi-purpose (can be used for a range of purposes or situations)
- **low-impact fabrics** – using unbleached and chemical-free, organic, undyed or naturally coloured where possible, colourfast or biodegradable dyes for colouring synthetic fabric, components made from the same material for easy recycling, use of recycled materials
- **components or notions** – using natural and renewable, recycled or recyclable
- **clothing production** – minimising waste when laying out cutting plans, simple machining processes that use less energy, use of renewable or 'green' energy
- **clothing use** – considering durability (strength of fabric and construction, classic style), choosing fabric that can be washed at a low temperature and doesn't need to be ironed frequently, providing good labelling for correct maintenance, avoiding fabric or construction that requires dry-cleaning
- **disposal** – developing or using systems for clothing and fabric recovery and reuse, designing for the easy separation of different materials.

Strategies for wood, metal and plastic products

Environmental design strategies for wood, metal and plastic products include:

- **materials** – reducing the range of materials used (ease of recycling); reducing the amount of material without compromising strength and safety; using renewable, recycled or recyclable materials; minimising the use of timber products that use formaldehyde binder; excluding solvent-based or hazardous glues and finishes; selecting timber from sustainably managed forests; selecting metals that have lower levels of **embodied energy**; selecting bio-plastics where possible
- designing for **disassembly** – not gluing different materials together; labelling plastics for effective separation and recycling
- **production** – minimising waste, reducing the number of components from different materials, simplifying construction to reduce energy use, using renewable or 'green' energy, eliminating toxic waste
- **use** – designing to function well (for durability and the ability to be repaired and maintained for a long life)
- **recycling** – use of appropriate symbols for materials, making sure materials can be separated easily and without cross-contamination, avoiding the use of composites or laminates, reducing fitting and parts for ease of disassembly, establishing systems to recover materials.

embodied energy the total energy required in all stages of production

Strategies for electrical and electronic products

Even though the Study Design doesn't cover the production of electronic products, it is worth considering the environmental design strategies for electrical and electronic products. These include:

- **materials** – avoiding toxic, ozone-depleting materials and processes, selecting recycled and recyclable materials
- designing for **energy efficiency**
- minimising errors and waste in production

9780170400336

- designing for **durability** – so the product is strong, functions well, doesn't become outdated quickly
- designing so that the product can be **upgraded, repaired and serviced**
- **standardising** parts and add-on connections, allowing for interchangeable parts, having standard connections that don't change frequently with new models (so add-ons and external devices don't have to be replaced)
- designing for remanufacturing and **material recovery** – easy disassembly, reuse of components and recycling.

Environmental design frameworks and concepts

Environmental design frameworks and concepts help designers and manufacturers to develop strategies to minimise their environmental impacts. *They include those outlined on pages 358–60*:

- design for disassembly
- extended producer responsibility/product stewardship (*see page 359*)
- 'Cradle to Cradle' thinking.

There are other useful environmental concepts, such as:

- upcycling
- embodied water, embodied energy and embodied carbon.

'Upcycling'

Most recycled materials are made into new materials of lesser quality. Each round of recycling reduces the quality and usefulness of the materials, and this can be termed 'down-cycling'. 'Upcycling' is where the by-products and materials (including waste materials) from existing products are reclaimed for better value. It saves wastage and reduces the need for new materials and other resources, such as air, water and energy. Resulting products can be of better quality, higher value or more use. 'Upcycled' products that have been handcrafted from recycled materials are usually more valued by the owner than the original product and are kept in use for a longer period of time.

Embodied water, energy and carbon

Embodied water

Embodied water does not refer to the amount of water present in a product; it is a way of quantifying the amount of water used in creating and processing the product's materials, and in the production of the product. For example, the embodied water of a T-shirt would include the water used to grow the cotton, clean it and dye it. A 500-gram shirt embodies approximately 4100 litres (L) of water.

Embodied energy

The embodied energy of a product refers to the amount of energy used to source and process materials, produce and transport the product, and dispose of the product. It is usually measured in megajoules per kilogram (MJ/kg) of product. An average car embodies 270 000 MJ of energy, or the energy released by burning 7200 L of oil.

The impacts of different materials used in products can be compared by carefully considering their embodied energy.

9780170400336

The embodied energy in different materials

Material	Embodied energy (MJ/kg)	Material	Embodied energy (MJ/kg)
Wood	2–8	Copper	115–180
Natural rubber	5–6	Steel	60–72
Natural fibre fabrics	4–10	Aluminium	235–335
Synthetic rubber	125–145	Gold alloy	5600–6000
Manufactured timber products	6–12	Foam (polyurethane)	140–160
Nylon	170–180	Carbon fibre	800–1000
Glass fibre	20–150	Melamine	120–150
Glass	20–25	Polypropylene	90–115

Embodied energy values sourced from Alastair Fuad-Luke, *The Eco-Design Handbook*, p. 283

Embodied carbon

Embodied carbon is the amount of greenhouse gases released into the atmosphere as a result of creating a product, and is often related to the amount of energy needed to source, make and transport the product. It is measured in tonnes of CO_2 per kilogram of product. However, the amount of greenhouse gases created by a product and its embodied carbon may be reduced if the source of energy used is not a fossil fuel (i.e. it is solar, wind, thermal, hydro or nuclear power) and if there is minimal transportation involved.

Greenwashing

Greenwashing is a negative term, indicating that an organisation is trying to gain 'green' or environmental credibility without deserving it. An organisation might create the impression that a product, a service or their brand is environmentally responsible when it is not (e.g. by deceptive packaging, manipulative or selective use of data, or meaningless 'green' certification), or it might focus on a small positive action of the organisation in an effort to distract attention from larger negative impacts.

Greenwashing can mislead consumers about a product's attributes or an organisation's environmental practices in terms of sustainability. Unfortunately, this tends to make consumers suspicious of all sustainability claims.

Social sustainability

Does the development, manufacture and use of a product contribute to society in a positive way? That is the question designers and manufacturers need to ask when considering the social impacts of a product. To assess whether a product is socially sustainable, designers need to think about the following areas.

When the materials are sourced

- Are the farmers, miners, foresters, etc. given a fair/living wage for their work?
- Does this disrupt traditions and cultures of communities?
- Does this damage the health of people in local communities?

9780170400336

Production of materials and products

- Are workers fairly paid – provided with a living wage?
- Does manufacturing damage the health of local communities (e.g. through waste and pollution)?
- Does the community benefit from the manufacturing industry (e.g. increased prosperity, health and education services)?

Transporting materials and products

- Does transport infrastructure (roads, railways, etc.) disrupt communities?
- Is it costly?
- Does the infrastructure provide benefits to the community?
- Does transportation cause unhealthy pollution?

Product use

- Does the product change the lifestyle of people, making them more/less healthy?
- Does the product change the way people interact with each other?
- Are the benefits of the product accessible to all?

Product disposal

- Does the product cause health problems when disposed of?
- Do some communities carry an unfair load in terms of landfill and pollution?

When considering the social impact of their products, most companies focus on the first two areas – these are the areas where they have most control. Socially aware companies aim to have transparent **supply chains**, making sure they know where their materials are coming from, who processes materials and who manufactures the product, and ensuring workers are given fair treatment and a living wage. Companies with **Fairtrade** accreditation go even further – they pay a premium on top of the workers' wages, which is paid to the community for health and education projects.

supply chain the activities and people that link the conversion and movement of raw materials all the way through to the finished product

United Nations

The United Nations has developed '10 Principles for Sustainable Development', covering human rights, labour, the environment and anti-corruption. Six of them directly relate to the way businesses treat people, and Principle 10 relates to economic responsibility.

Human rights

Principle 1: Businesses should support and respect the protection of internationally proclaimed human rights; and
Principle 2: make sure that they are not complicit in human rights abuses.

Labour

Principle 3: Businesses should uphold the freedom of association and the effective recognition of the right to collective bargaining;
Principle 4: the elimination of all forms of forced and compulsory labour;

Principle 5: the effective abolition of child labour; and
Principle 6: the elimination of discrimination in respect of employment and occupation.

Anti-corruption

Principle 10: Businesses should work against corruption in all its forms, including extortion and bribery.

Source: United Nations Global Compact website

Economic sustainability

Triple bottom line

The **triple bottom line** – a form of accounting that considers people, planet and profits – is broader than the purely financial 'bottom line' of traditional accounting, which considers only commercial interests. The triple bottom line also considers the 'costs' of actions in social and environmental terms. It argues that commercial organisations should see and take note of their responsibilities to all **stakeholders** (all people impacted by their actions), rather than just to their shareholders (those who benefit financially from the organisation's business).

triple bottom line a type of company reporting, broader than the purely financial 'bottom line', that also considers the social and environmental 'costs' of actions

stakeholders people who are involved with, or impacted by, a situation

Full-cost or true-cost accounting

This considers not just the immediate financial costs and benefits of an action, but also all of the 'ripple' effects and consequences. This concept involves organisations:

- taking responsibility for ongoing costs, rather than just the initial financial outlay
- considering hidden, indirect and overhead costs, and costs outside the organisation (broader impact)
- considering the broader economic costs of the environmental and social impacts of a product (or of a company's actions)
- accounting for past and future costs for the whole life cycle of a product.

Corporate social responsibility

Corporate social responsibility (CSR) involves organisations and businesses committing to self-regulation to monitor how well they comply with the spirit of the law, ethical standards and international norms. Organisations that put CSR principles into action are expected to actively promote the 'public good' by going beyond legal requirements – e.g. by encouraging community development, voluntarily removing practices that might harm people, and considering the public interest when corporate decisions are made.

For a wider discussion of the connection between economics and sustainability, enter terms such as 'ecological economics' or 'green economics' into a search engine.

Regulations, standards and certification

Regulations and agreements

There are rules that regulate areas of environmental and safety concern. These are applied by governments, and have to be met by manufacturers of products sold in the regulated region.

- The **Restriction of Hazardous Substances Directive (RoHS)** puts limits on the use of six specified hazardous materials in electronic equipment.

9780170400336

- The **Waste Electrical and Electronic Equipment Directive (WEEE)** places the responsibility for the disposal of electrical and electronic goods on their manufacturers.
- The Australian Government has developed **product stewardship** legislation (2011) that covers mandatory and voluntary codes for the disposal of different products at the end of their useful life.
- The **UN Basel Convention** (international) limits the movements of hazardous materials to reduce the amount of materials generated by developed countries being dumped in developing countries.
- There are a range of environment protection laws managed by each state in Australia, and the national *Environment Protection and Biodiversity Conservation Act 1999* is administered by the federal government. The aim of such laws is to is to provide a legal framework to protect important flora, fauna, ecological communities and heritage places. These laws can be used to regulate manufacturing industries and fine those who pollute.

Standards

Standards give consumers confidence that a product and its producers meet criteria in the area covered by the standard. In the environmental, social responsibility and quality areas, ISO standards are voluntary and are developed by the International Organization for Standardization.

- The **ISO 14000 Environmental Management System** series of voluntary standards (international) provides a systematic approach for manufacturers and other organisations to improve their environmental performance.
- The **ISO 26000 Social Responsibility** series of standards (international) provides guidance and principles for socially responsible actions within public and private sectors.
- The **ISO 9000 Quality Management** series of voluntary standards (international) defines recommended practices to help companies provide consistently good-quality products and services, and meet customer expectations. (Note that good quality increases the durability of a product, making it more sustainable.)

Environmental certification

Forest Stewardship Council

FTAANZ

Environmental certification accredits companies that have gone through rigorous assessment to check that their practices meet expected guidelines. Companies are assessed by independent organisations with responsibility for particular areas:

- The **Forest Stewardship Council (FSC)** sets standards for the environmental, ethical and socially responsible management of forests. Companies can ask for their products, processes or services to be accredited, and if they are, the FSC trademark can be used.
- The **Australian Furniture Research and Development Institute (Furntech-AFRDI)** has developed an Australian-based sustainability standard (the AFRDI 150 Standard) and an associated certification process for furniture products. Companies and products that gain certification are allowed to use the AFRDI 'Green Tick'.
- To gain **Fairtrade** accreditation, companies have to prove to the **Fairtrade Labelling Organisation (FLO)** that they meet minimum standards that include the protection of workers' rights and the protection of children, the preservation of the environment, payment of the Fairtrade Minimum Price and an additional Fairtrade Premium to invest in initiatives to support local communities or business development. The Melbourne company Etiko was the first non-food company in Australia or New Zealand to gain Fairtrade accreditation. Link to the Etiko website via http://nelsonpdtvce.nelsonnet.com.au.

9780170400336

- **Good Environmental Choice Australia (GECA)** assesses environmental and social impacts and gives companies permission to use the label on their products and marketing.
- **Ethical Clothing Australia** is a voluntary accreditation organisation for the clothing industry. Companies that carry the label must prove that their supply chains are transparent and legally compliant.
- Certified **B Corporations** have achieved a high standard when the following areas are independently assessed – corporate governance, transparency, environmental and social impact.
- **Carbon Trust** – certification indicates that companies have taken significant measures to reduce their carbon footprint, as assessed by the independent Carbon Trust organisation.

CASE STUDIES FOR SUSTAINABLE DESIGN

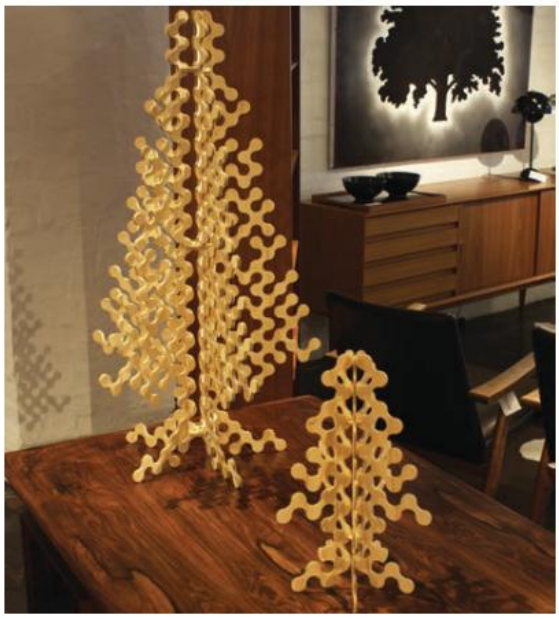
CASE STUDY

Büro North: the Büro tree – product design and wayfinding

COMPANY BACKGROUND

Büro North is a multidisciplinary design practice, established in 2004. Led by Design Director Soren Luckins and Wayfinding Strategist Finn Butler, the diverse team works across the disciplines of graphic design, industrial design and **wayfinding**.

wayfinding the development of signage, displays and the management of moving people through spaces



Büro North, www.buronorth.com

Büro trees

THE BÜRO TREE

What was the motivation for developing the Büro tree?

In 2007, Büro North decided to design a green product as an alternative to the traditional Christmas card for their clients. It also saw its potential as a greener alternative to the traditional Christmas tree. It wanted to create a product that had a modern design aesthetic and a significantly smaller ecological footprint. The solution was a locally sourced plywood tree that was sealed in linseed and flat-packed into recycled, aged, cardboard packaging.

What research was carried out?

Every step of the process was carefully considered to find the most sustainable compromise.

- Many design workshops were run to discuss the possibilities for the design outcome, and Büro North's industrial designers and Design Director, Soren Luckins, researched possible materials and construction methods.
- Local and interstate manufacturers were investigated to decide the best avenue, balancing the cost and the ability to deliver Büro North's design intent.
- Before any Büro trees were produced, a life cycle assessment (LCA) was undertaken to measure the carbon, water, energy and waste impacts of normal Christmas trees. The same process was undertaken for the proposed design. The proposal was 80 per cent more environmentally efficient.

9780170400336

What eco-design strategies are incorporated into the Büro tree?

The Büro trees have been designed for sustainability along every step of the supply chain – from the raw material, via production, through to the customer.

- The Büro trees are made from locally produced plantation-pine plywood, which is durable, attractive and more sustainable than all other viable alternatives. By using a robust material, the trees can be reused year after year.
- The design eliminated the use of glues and mechanical fixings – the pieces slot together to form the product.
- The design of the cutting template utilised clever layout to interlock the forms. This minimised waste.
- The CNC [computer numerical control] routing process employed to cut the trees is a low-energy process that allowed for batch production to be matched to consumer demand for just-in-time production.
- The plywood had been enhanced and protected with non-toxic linseed and citronella oils.
- Despite being cheaper to produce offshore, the trees are produced by an Australian manufacturer, reducing the distances travelled. The trees can be flat-packed for transporting, which lowers emissions.
- The 2D design can be dismantled and stored easily between seasons, encouraging repeated usage.

How was the LCA for the trees carried out?

Büro North engaged a specialist to perform an LCA on the process of clear-felling land, growing pines, chopping them down at maturity, transporting them 100 kilometres to Melbourne on a light truck, then transporting them an average of 10 kilometres in a small car, then throwing them into hard rubbish at the end of January where they go to create landfill. This was compared with the impacts of sourcing and processing the plywood, cutting the design, transportation, and the disposal of the tree after five years.

Büro North, www.buronorth.com

The Büro tree can be flat-packed for easy transporting and storage

What were the results?

Based on the LCA report (conducted by Nick Johns of Black Panda), the plywood Büro tree creates a significantly smaller ecological burden when compared with the consumption of traditional pine Christmas trees. The resource wastage and transport emissions created by the growth, transportation, use, maintenance and disposal of five pine trees cause significant destruction to the natural environment and deplete natural resources. Over the same five-year period, the repeated use of the plywood Büro tree alternative creates minimal solid waste and emissions. While the Büro trees clearly outperform the traditional pine tree over a five-year period, this aesthetically engaging product is likely to be kept for a longer period, increasing the environmental benefit.

What other methods were used to evaluate designs and the finished product?

Büro North tested the product out at local design markets to assess the feedback from the marketplace.

Büro North doesn't carry out LCAs on all its products. Why not?

The more complex the project, the more cost-prohibitive it is to carry out an LCA. The Büro tree is a relatively simple product with few materials, so the LCA was straightforward and the costs were manageable.

9780170400336

ECO-DESIGN STRATEGIES

How does Büro North incorporate eco-design strategies into the design of its other products?

Büro North is a 'carbon neutral' business. Through an energy, waste and carbon auditing process, it has developed measurable performance indicators for minimising its business footprint. It offsets the travel and business emissions it does incur.

On all projects, Büro North specifies:

- sustainable, low-energy production
- the use of materials that meet Forest Stewardship Council standards
- vegetable oil–based inks
- recycled content papers
- locally sourced products and suppliers.

The company invests substantial amounts of time and energy developing knowledge, supply chains and contacts for its clients' projects.

Due to the studio's commitment to conducting itself ethically and contributing to economic development while improving the quality of life of the local community, it provides design and management skills to a number of organisations without pay. The studio has sponsored design work for Mercy Care, the Clothing Exchange, the Next Wave Festival and the Melbourne Design Festival, as well as an exhibition that showcased works by artists about people living with acquired brain injuries (ABI).

A link to the Büro North website is provided at http://nelsonpdtvce.nelsonnet.com.au.

Information provided by Soren Luckins, Design Director, and Missy Saleeba of Büro North

CASE STUDY

Etiko: ethical clothing, shoes and sporting equipment

Etiko

Etiko sneakers

Who made your shoes? Do you know who made your T-shirt? Were they paid and treated fairly?

These are questions that Nick Savaidis often asks people. They are questions he asked himself many years ago. Nick's mother was an immigrant from Greece who supported her family by doing piecework (being paid for each garment she made). As a teenager, he was shocked to find that the clothing his mother made was sold at a price about 100 times the payment she received.

After teaching in Melbourne, Nick worked with the Central Australian Indigenous community at Yuendumu (300 kilometres north-west of Alice Springs). Through his teaching, Nick wanted to develop students' practical life skills and build their independence. He helped the community set up a number of social enterprises, ranging from a shirt printing business to a videoconferencing network. He also wanted to ensure that the Indigenous community benefited socially and financially from these enterprises.

Back in Melbourne, Nick found a different channel for his commitment to social justice. He remembered the experiences of his mother, and felt there was a need to create a bridge between the farmers who grew materials, the makers of clothing, and consumers who wanted clothing, footwear and sporting goods that were equitably and

9780170400336

environmentally sourced. Looking at how large global corporations operated, Nick felt there had to be a better way of doing business.

ETIKO AND JINTA

And so, Etiko and Jinta were born – Etiko, the Greek word for 'ethical', and Jinta, a Warlpiri word for 'one' or 'winner'. The company behind both brands is based on the principles of fair and equitable treatment of workers, transparent supply chains (knowing exactly where all materials come from and where manufacturing is done) and reducing the environmental impact of products.

The Etiko brand covers clothing – T-shirts, hoodies, underwear, sneakers and thongs. All of the cotton used in clothing and sneaker uppers is organically grown and Fairtrade certified. Etiko was the first non-food company in Australia or New Zealand to achieve Fairtrade certification. The rubber used in the base of the sneakers and the thongs is a mix of FSC-certified natural rubber and some recycled rubber. All materials are natural, hardwearing, and will decompose when disposed of.

The sporting goods (soccer and footballs, basketballs and netballs) that are sold under the Jinta brand are all Fairtrade certified. They were also guaranteed child labour–free long before the scandalous practices of leading sportswear and sporting goods companies were revealed. Workers in Pakistan and India are treated with dignity and paid living wages, and the Fairtrade premium (additional money paid to the community as part of the Fairtrade accreditation) is used to support educational programs for their children. Nick knows his supply chain, and regularly visits the farmers who grow resources and the workers who manufacture fabrics and products. Funds from the sale of Jinta sporting goods also support a number of remote Indigenous communities through the Warlpiri Youth Development Aboriginal Corporation.

WRAPPED AND PACKAGED

Another focus for Nick is the packaging of products. This needs to have as little environmental impact as possible. The primary packaging material used is recycled cardboard, which can be recycled again and decomposes easily. Etiko shoes are packaged in a lightweight recycled cardboard, thongs are held together with a cardboard hanger (unlike the plastic ones commonly used and thrown away). Clothing and thongs are wrapped in plastic to keep them clean during transportation and

Etiko

storage, but this is made from cellophane, a plant-based plastic that quickly breaks down in the environment. Nick is constantly researching materials, always looking for ways to lessen the environmental impact of his products and their packaging. He is in direct contact with a plastics development company in Indonesia that is investigating a new bioplastic alternative, made from the cassava plant, for packaging clothing.

A WIDER MARKET

The Etiko and Jinta brands are successful on a certain level. However, for his products to make an impact, Nick realises that he needs to reach many more people than those who are already motivated to make sustainable choices. The products have to appeal to the mainstream – to tell an ethical story to a wider audience. He feels that the products are right: Etiko clothing and footwear and Jinta balls are of high quality and are priced competitively (usually just below 'brand' products). However, at present they are only available through 'alternative' retailers and via the Etiko website, and haven't been picked up by mainstream retailers. Another service Etiko provides – printed clothing, uniforms and accessories for organisations and corporations – has impacted on some large players. A number of Melbourne's universities purchase their logo hoodies and T-shirts through this Etiko service.

In 2017, Etiko was awarded development funding to increase the reach of the business. Nick is very excited that this will give him the time, staff and money to work on increasing his company's mainstream profile, and to help streamline and speed up his delivery response times.

9780170400336

OVER TO YOU

Nick has some questions for VCE students:

- *Do you know where your school uniforms are made?*
- *Does your sports department know who makes their equipment, and can they be sure they are made without child or sweatshop labour?*

He is frustrated that many schools promote values of equity, social justice and compassion, but do not put these values into practice. Nick wants students to ask these questions and demand more of their school community's choices. He also wants students to question their own purchasing choices and be aware of companies that might 'greenwash' or 'ethically wash' their products.

Etiko was launched in November 2005 and has won the following awards:

2016	Australian Human Rights Award (Business Category)
2013–2016	Australian (Ethical) Fashion Report (Highest Ranking Brand)
2013	Australian Fairtrade Awards (Winner – Fairtrade Product of the Year)
2012	Sustainable Living Foundation (Golden Greenie Award)
2009	Australian Organic Expo (Silver Award/ Product Innovation)
2008	Premier's Sustainability Award – Winner: Small Business (Victoria)
2008	Banksia Environment Foundation Award – Winner: Business Sustainability (National)
2008	Telstra Business Award – Winner: Social Responsibility (Victoria)
2008	FSC Responsible Forest Management Awards – Small Chain of Custody Operator of the Year.

Nick Saviadis was interviewed by Jill Livett at the Etiko headquarters in Croydon South. A link to the Etiko website is provided at http://nelsonpdtvce.nelsonnet.com.au. Read about the philosophy and products of Etiko (clothing and shoes) and its offshoot company Jinta (sporting equipment).

Etiko

Nick Saviadis (second from right) and his Etiko team

CASE STUDY

Cantilever: environmental thinking in practice – cabinetry

- **Design focus** – high-quality, environmentally responsible design
- **Products** – Cantilever has developed and produces a series of standard kitchen designs: K1, K2 and K3. They also develop custom kitchen designs for clients, and make other interior/furniture products, usually in conjunction with a kitchen project. Cantilever's work has a distinctive style, mainly due to the choice of materials (environmentally sustainable), and the designers' use of clean lines, accentuated by the exposed plywood edges and strong flashes of colour
- **Location** – a design studio and workshop in Brunswick, in the inner north of Melbourne
- **People** – a staff of 11, led by directors Travis Dean and Charlie Wilde

BACKGROUND

Peter Tragardh-Daly, Travis and Charlie started working together at 3 Phase Design. They come from a variety of backgrounds, but all with strong design and production training and experience. When they recognised in each other a similar approach and

9780170400336

philosophy, they decided to trial working together. From this start, Cantilever was formed, and after a few years, the company moved to its current studio and workshop site. The company now makes and installs kitchens in Melbourne, Sydney and in other states.

HOW CANTILEVER WORKS

Cantilever's workflow is organised through three teams focusing on:

- front of house (customer service)
- design
- production and installation.

The 'front of house' team, led by Travis, fields most enquiries. They explain the kitchen options and the philosophy underpinning the designs, and clarify the clients' needs. The first site visit is organised to get an understanding of the kitchen space. A basic layout drawing is produced at this stage.

Charlie's design team then works with this information to complete detailed CAD drawings of the kitchen (using kitchen-design software called Microvellum, individualised for the company). Cantilever sources the chosen appliances and fittings for the client to ensure the design will contain them perfectly. This team also coordinates with the builders to ensure the correct positioning of services (water, gas, electricity) and to organise scheduling for installation.

The production team is led by Brendan West, the workshop manager. They are responsible for material management and production workflow through the following stages:

- prefabrication (cutting, edging and finishing of surfaces and edges) – highly detailed CAD drawings are used to drive a CNC machine, which accurately cuts and shapes the kitchen components
- carcase assembly
- a complete set-up on the build platform (including fitting appliances and hardware) and measuring/making benchtop templates
- partial disassembly, wrapping, transportation and final installation on site.

There are various sign-off points for the client at different stages of the process.

SPECIFIC ENVIRONMENTAL STRATEGIES

The partners and staff at Cantilever feel that environmentally responsible ideals are embedded in all of the decisions they make. They use a range of practical sustainable strategies throughout the design and production process.

Choice of materials

Cantilever incorporates a number of environmentally responsible materials in its products.

For the carcases, this means either:

- HMR particle board – moisture-resistant and 'E Zero' (emitting very low amounts of toxic gases)
- laminate on plywood.

For the doors, either:

- laminate on plywood
- veneer and water-based 2-pack finish
- laminate with ABS edging, and hoop pine plywood for details and features.

For benchtops, either:

- laminate on ply (hoop or birch)
- reconstituted stone (preferably, with some recycled content).

Plywood is a more sustainable manufactured material than many others. It creates very little waste as the veneers are peeled from logs rather than

cut; it also has a higher strength-to-weight ratio than manufactured boards (increasing the product's durability and extending its life) and the glues that bond the layers don't emit volatile organic compounds (VOCs); the plywood has a layer of white laminate on the surface, instead of the conventional melamine (which is thinner and less durable).

Some of these materials are produced specially for Cantilever. The company also sources custom-made stainless-steel sinks and handles that are produced locally, and they are currently in discussions with a local tapware manufacturer.

Choice of finishing materials

- All of the finishes Cantilever uses in-house are water-based and emit no VOCs.
- Other companies that carry out more complex finishing tasks for Cantilever filter all exhausted air from the finishing process to ensure that all harmful chemicals are trapped. Workers are protected by full suits and sealed masks.

Buying and working locally

Distances of all travel and transportation are kept to a minimum:

- Materials are sourced in Australia wherever possible, preferably in and around Melbourne.
- Most of the outsourced work is carried out by companies located in north-west Melbourne.
- Many of the Cantilever staff live close enough to cycle to and from work daily.
- Cantilever is part of a growing network of local organisations that recycle and repurpose material offcuts and waste. (Unfortunately, the company is too small for most large-scale industrial recycling programs.)

High quality and durability

- The materials, the joining processes, the precision that is used during design and production, and the timeless nature of Cantilever designs (not driven by the fads and fashions of the interior design industry) ensure that Cantilever products last for much longer than alternative products.
- High-quality hardware is used – Cantilever sources all of its hinges, runners, handles, etc. from Blum, a company that has ISO 14001 certification.
- Regular checks are made during the design and production process, particularly at the trial set-up stage on the 'platform' (a solid, level, raised area, used for testing units for accuracy) – nothing goes out of the production area for installation unless all problems are resolved.

Renewable energy sources

Cantilever sources its energy from Powershop, an electrical supply company that has environmental and socially ethical practices. Cantilever would love to buy solar panels to generate their own power, but they are currently too expensive.

ENVIRONMENTAL STRATEGIES CLOSER TO HOME

So far, most of Cantilever's obvious environmental strategies have focussed on the products (using design and production processes that are as sustainable as possible). Cantilever is now considering its business work practices, aiming to create a more liveable and healthy work environment for the staff. They are continually evaluating and improving their practices, and developing sustainability goals for the future in all aspects of design, production, distribution, packaging and office work.

THE ECONOMICS OF SUSTAINABILITY

Sustainable choices can be costly – all the materials and components used by Cantilever are expensive, whether custom-made or carefully selected. Quality processes also take time and are costly. Cantilever's original custom-designed and -made kitchen work was expensive, and most clients needed to be affluent. Cantilever wanted to make sustainable kitchens more accessible, which led to the development of its standardised kitchen range. These are still high in quality, but involve less design time, making them less costly. The three designs – K1, K2 and K3 – vary in the cost of materials and hardware, but all are treated equally in terms of build quality. Through increased efficiency in the design and production stages and in the company's business systems, Cantilever has absorbed most of the increases in material costs for the past five years.

'Repetition creates refinement.' Because, over time, Cantilever has built many of the same or similar products, its solutions are more resolved and work better, and its processes of waste reduction (in time and materials) have improved. As a result, the K1, K2

and K3 kitchens are now better, but less expensive in real terms.

The team at Cantilever are really proud of their growth as a company – it proves that their practices, driven by a sustainability philosophy, are viable and economically beneficial.

STRATEGIES CURRENTLY OUT OF REACH

These include **ISO 14001 certification** – it would be great to have environmental standards certification, but the process takes years, is expensive and entails lots of staff time just to keep up with the required research and paperwork.

RECOGNITION

The high quality and environmental design work of Cantilever is gaining industry and media recognition. Its work has been profiled in a number of 'green' magazine articles. Cantilever contributed major cabinetry work to Brunswick's Westwyck development – this 'green eco-village' development has been profiled by a number of magazines and has received major industry awards from IDEA (Interior Design Excellence Awards) and the Australian Institute of Architects.

Kylie Forbes from Cantilever was interviewed by Jill Livett at the Cantilever studio and workshop.

You can link directly to the Cantilever website via http://nelsonpdtvce.nelsonnet.com.au. Go to 'Sustainable practices' (in the 'About' section) for information on the company's strategies, materials and design.

iStockphoto.com/pixelfit

SECTION 2

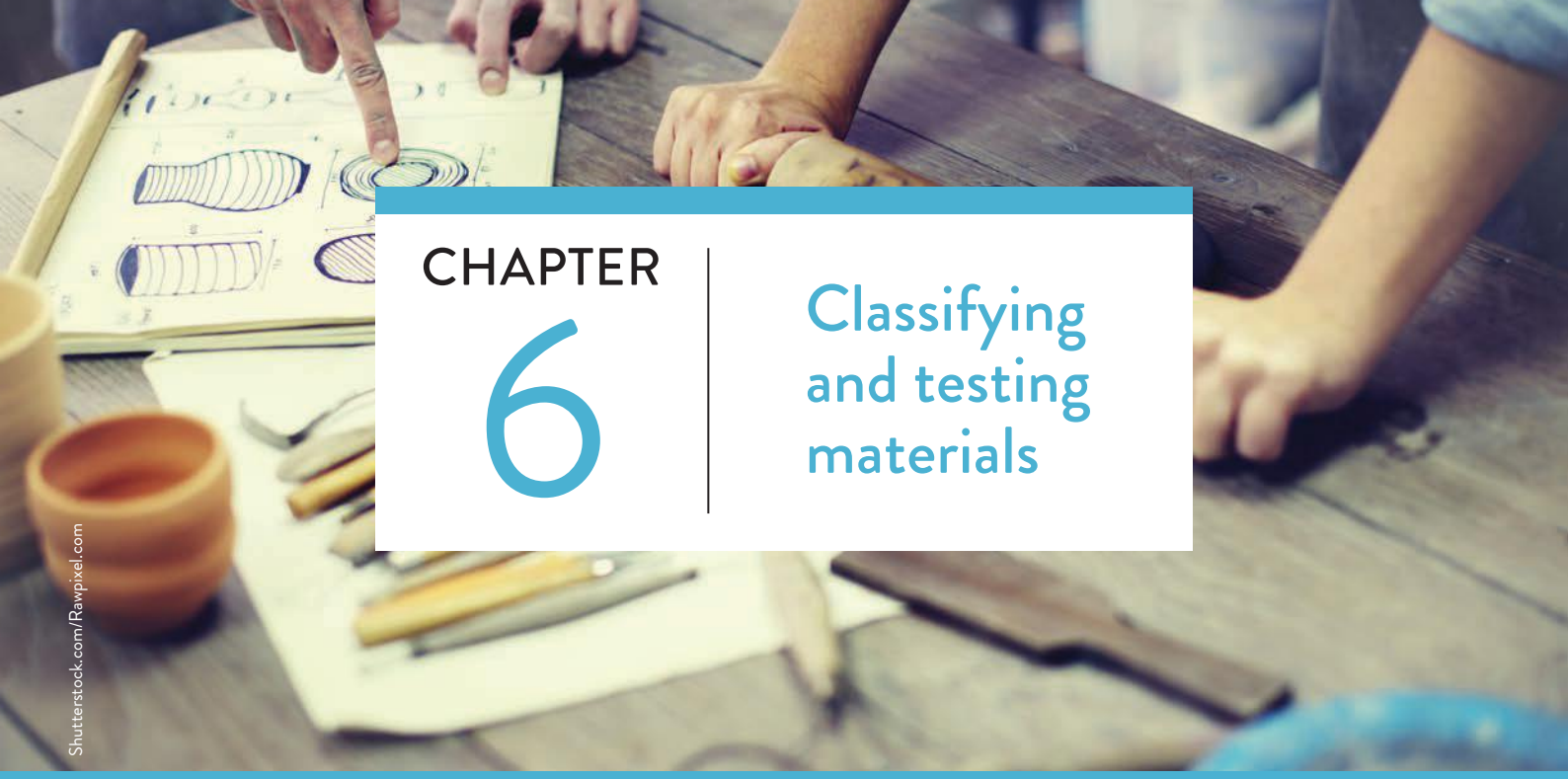
MATERIALS AND PROCESSES

Chapter 6: Classifying and testing materials 140

Chapter 7: Resistant materials and processes 158

Chapter 8: Non-resistant materials and processes 214

9780170400336



Shutterstock.com/Rawpixel.com

CHAPTER 6

Classifying and testing materials

CHAPTER FOCUS

In this chapter you will learn about:

- Classifying materials p. 140
- Resistant materials – forces, effects, characteristics and properties p. 142
- Non-resistant materials – characteristics and properties p. 147
- Materials testing for all materials – including tests p. 151

CLASSIFYING MATERIALS

The diversity of materials that are available creates the need for effective methods of classification. There are many ways of classifying materials, depending on the purpose or reason for classifying.

A simple level of classification defines the material according to its resistance, i.e. what happens when it is pushed, pressed or bent? Does it move easily or resist? There are other classifications of resistance in use, such as fire resistance, water resistance and stain resistance, but for the purposes of this study, we use the classification in the table below. Each of the dot points in the table is a material category.

Non-resistant and resistant materials

Non-resistant categories	Resistant categories
Materials that are flexible, easily moved, bent and shaped; materials that can be used to cover surfaces: • fibres, yarns and fabrics • plastic film • rubber and leather	Materials that are generally solid in form (at room temperature) and, because they show only a limited amount of flexibility, are often used for structural purposes: • wood • metal • glass • ceramics • solid plastic • stone • concrete

9780170400336

The predominant method of classifying materials for VCE Product Design and Technology is the 'classification within categories' method. It is helpful to be aware of the classification of all material categories, but it is critical to have a detailed knowledge of the classifications within the category/categories of materials you are using. Note that this method of classification may conflict with classifying materials according to their resistance, e.g. plastic can be resistant or non-resistant, depending on its chemical structure.

Each of the major material categories (wood, metal, fabric, plastic, etc.) is broken into a number of subgroups, and placement of material within a subgroup is usually determined by its source or its chemical structure. Materials in these subgroupings often have similar **characteristics** and/or **properties**. Some of the main subgroups are then further broken into minor groupings.

characteristics and properties the physical and chemical structure of a material; how it looks, feels and behaves under different conditions

Material	Major classification subgrouping	
Wood	Softwoods	
	Hardwoods	
	Manufactured boards	
Metal	Ferrous	
	Non-ferrous	
	Alloys	
	Coated metals	
Plastics	Thermosetting	
	Thermoplastic	
	Composites	
Fabric, fibres and yarns	Natural	Protein (animal)
		Cellulose (plant)
	Manufactured	Regenerated (cellulose-based)
		Synthetic (petrochemical)
	Blended and laminated	
Ceramic (clay-based)	Earthenware	Terracotta Raku (firing process)
	Stoneware	
	Porcelain (Bone china)	
Cement		
Glass	Soda lime	
	Lead glass (crystal)	
	Float, laminated, toughened	
	Borosilicate	

Classifications are explained in more detail in Chapters 7 and 8.

9780170400336

Materia and the Material ConneXion

Materia is a large online library of materials – some are innovative and newly developed, while others are traditional or indigenous to a region or community. You can search for materials – these are described briefly and then rated in terms of their 'sensorial' and technical qualities.

The Material ConneXion is a commercial library, charging a fee for their materials search, but it also has lots of free information regarding the latest developments in materials.

Go to the Materia website and register, and then search the materials database. For the Material ConneXion, go to the website, select 'Materials' and then 'New materials'. Links to both websites are provided at http://nelsonpdtvce.nelsonnet.com.au.

RESISTANT MATERIALS

Forces and effects

To make effective use of materials, a designer must understand how materials respond to the application of external forces, such as tension, compression, bending, torsion and shear, all of which are discussed below.

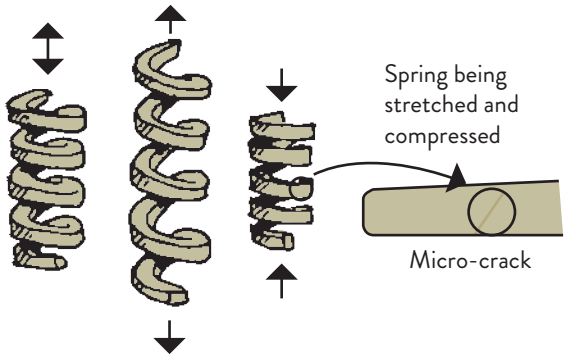
Types of forces/effects

Depending on the size of the force applied, solid materials will display one or more of the following reactions/effects under load:

- **elastic deformation** – where the material stretches/moves when a force is applied, and then returns to its original shape on release of the load
- **plastic deformation** – where the shape of the material is changed through the application of force
- **rupture** – where the material fails to take the load and breaks.

Other types of failure, including fatigue and creep, involve the application of force over extended periods of time.

cyclic loading repeated loading and unloading, or applying a load over and over



Fatigue in a spring

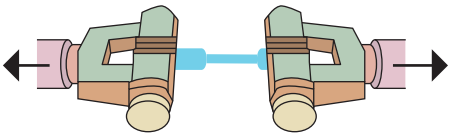
Fatigue can be defined as a progressive fracture in the material. It occurs when mechanical parts are subjected to **cyclic loading**, bending or vibration repeatedly. No deformation is apparent, but small, localised cracks develop and work their way through the material, weakening it.

Creep is a slowly progressing form of permanent deformation, often induced by gravity or rotational forces. Turbine blades, long-span cables and engine components can all suffer deformation from creep. Materials subjected to high operating temperatures are the most susceptible.

9780170400336

Types of force

Tension is a pulling force (called **tensile force**) that acts in one direction (usually along the object's axis) and stretches the material until it changes, breaks or tears. Testing of this nature is usually performed on a tensiometer, which records the stress versus strain and produces a stress/strain curve to visually represent the material's reaction under load.

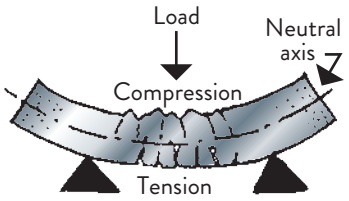


Tensile elongation

Compression is a pushing force that tends to shorten the object. Brittle materials such as glass or concrete will crush or fracture, while flexible ones such as rubber will shorten and increase their diameter.

Bending is unique, in that the application of a bending force will create both tension and compression forces within the one object. If a piece of aluminium is bent to form a curve, material on the outside of the curve will be in tension while material on the inside will be in compression.

A concrete pillar being crushed under compression



Bending force

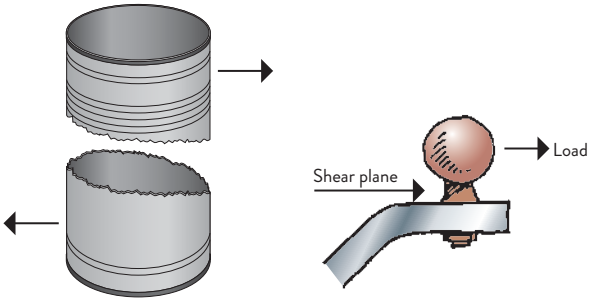
Shutterstock.com/tuanyick

Bent aluminium tubing, subject to compression and tension

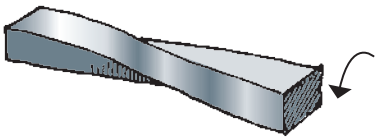
Torsion is a twisting force, such as is experienced in propeller shafts on a boat, or in a car axle.

Shear forces act at right angles to the material's longitudinal axis, and may be imagined as trying to cut across the material along a **shear plane**, like scissors cutting paper. The bolts securing a car tow-bar and the crankshaft of a combustion engine experience these types of load, as they can be cut or 'sheared' by the force.

shear plane the area where the shearing force occurs



Shear forces are exerted on the vertical 'bolt' of a car's tow bar when a trailer is attached



The twisting effect of torsion

Characteristics and properties

The range of characteristics and properties across the different classes of resistant materials is enormous. Appropriate use of a material depends on knowing its particular characteristics and properties, i.e. how it will behave.

There is a lot of overlap between characteristics and properties, and the terms are sometimes used interchangeably. These terms have specific definitions in particular technical fields. However, in this study we usually group them together for simplicity. The following pages refer mostly to properties, but some might also be termed characteristics.

Mechanical properties

- **Strength** is one of the most important properties since it determines a material's ability to hold loads without failure. Strength can vary greatly depending on how the forces of a load act on the material. Cast iron, for example, is strong in compression strength but comparatively weak in tensile strength.
- **Hardness** is the ability of a material to resist scratching, abrasion or indenting, and is closely related to strength. Sunglass lenses, for example, need to be scratch-resistant.
- **Elasticity** is the ability of a material to return to its original shape and dimensions when a **deforming load** is released. Bungee jumpers, for example, depend on the elasticity of the cords to absorb shock when they jump, and to return to their original shape for use by the next jumper.

deforming load
the load that stretches the material

- **Stiffness** or **rigidity** is the ability of a material to resist **deflection** under load. It is important in design, e.g. in shelving or sailboard fins.

deflection
the degree of movement; being bent or deflected

- **Plasticity** is the ability of a material to be permanently deformed without breaking. It is important when shaping processes are being considered, as the material may have to be heated or worked in a special manner.

Shutterstock.com/donatas1205

Bookshelves should not deflect or bow under a heavy load of books

- **Malleability** is a material's ability to manage all types of **plastic deformation** without damage. Gold, silver and other precious metals are well known for being malleable. They can be readily hammered into thin sheets or drawn into fine wire.

plastic deformation
permanent change in shape

- **Toughness** is the ability of a material to absorb energy when being deformed, and therefore to resist **deformation** and failure. Steel, for instance, would be considered tougher than window glass, particularly where suddenly applied impact loads are a concern.

deformation
change in shape due to force

- **Ductility** is the malleable ability of a material to be drawn out (stretched longitudinally) with a tensile force, yet remain intact, e.g. copper and gold can be pulled into thin 'wires' without breaking.

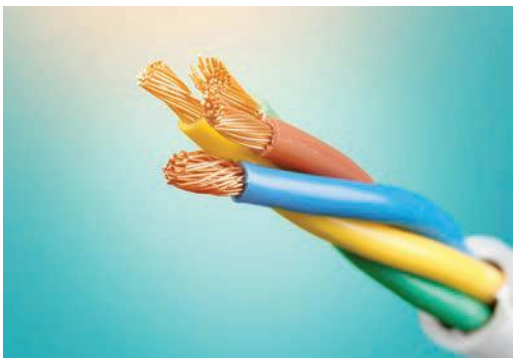
9780170400336

Physical properties

- **Density** is the mass per unit volume of a material. Materials of high density are comparatively heavy for their volume, e.g. gold and lead. Low-density materials seem light for their volume, e.g. balsa wood.
- **Porosity** depends on the number of holes or pores present in a material; it is usually expressed as a percentage of the total volume.
- **Moisture content** of a porous material can have significant effects on its strength properties. 'Green' timber, for instance, has different properties to seasoned wood. Many plastics also absorb water – enough to change their levels of strength and electrical insulation. The volume of a material may also be altered by moisture content. Changes in the volume of wood through moisture absorption or seasoning are the most obvious example of this effect.
- **Thermal conductivity** is the ability of a material to transmit heat. Metals are by far the best conductors because of their atomic structure. As the temperature of a material is raised, it normally expands (increases in volume).
- **Heat resistance** is determined by the melting point of a material, and its chemical stability and strength at high temperatures. Most heat-resistant materials are ceramic-based, but these have a poor resistance to thermal and mechanical shock (rapid changes in temperature, or being struck). This limits their application as moving components. On the other hand, metals such as tungsten, titanium and molybdenum retain their strength and toughness at high operating temperatures and remain heat and shock-resistant.
- **Electrical conductivity** depends on the material's structure and bonding, as flow of current relies on the movement of charged particles (usually electrons) throughout the material's atomic structure. All metals and carbon (in the form of graphite) are recognised as good conductors because of the many free electrons in their structure.
- **Corrodibility** refers to the vulnerability of a material to destruction due to chemical or electrochemical attack. We usually consider corrosion as being restricted to metals via oxidation (e.g. rust). However, non-metals, such as concrete and stone, are also susceptible to atmospheric and chemical attack.

Shutterstock.com/Joe Gough

Copper saucepans effectively conduct heat for cooking



Shutterstock.com/Billion Photos

Copper effectively conducts electricity

Shutterstock.com/Oleksii Fedorenko

Shutterstock.com/CHAIYA

Corrosion of metal (left) and concrete (right)

- **Durability** refers to how much damage a material can take before it breaks. It depends a lot on the forces applied, exposure to weather, chemicals and time, and the way it is treated.
- **Ease of machining** is not essentially a property but is related directly to the properties of the material being machined. For example, ironbark is an extremely dense, heavy and hard timber, which makes it difficult to machine. Ease of machining is definitely something to consider in the choice of materials for your projects.

Shutterstock.com/ben44

Fine, even-grained timbers are easier to turn on the lathe

Common properties of resistant materials

	Property	Wood	Metal	Plastic	Ceramic
Mechanical properties	Compression strength	Medium	High	Medium	Very high
	Tensile strength	Medium	High	Medium	Low
	Bending strength	Medium	High	Medium	Low
	Torsional strength	Medium	High	Low	Low
	Shear strength	Medium	High	Low	Low
	Hardness	Medium	High	Medium	High
	Elasticity	Low	Low	High	Low
	Stiffness	Medium	High	Medium	High
	Plasticity	Low	High	Medium	No
	Malleability	No	Yes	No	No
	Toughness	Medium	High	Variable	Medium
	Ductility	No	High	Variable	No

	Property	Wood	Metal	Plastic	Ceramic
Physical properties	Density	Variable	High	Variable	Variable
	Porosity	Variable	No	No	Variable
	Moisture content	Variable	No	Variable	Variable
	Thermal conductivity	No	Yes	No	No
	Heat resistance	Low	No	No	Low
	Electrical conductivity	No	Yes	No	No
	Corrosiveness	No	High	Low	Low
	Durability	Medium	High	High	Very high

NON-RESISTANT MATERIALS

An understanding of how non-resistant materials (such as fabrics, fibres and yarns) will perform under different circumstances is important in order to make sure that suitable choices of material are made for a situation. The characteristics and properties of non-resistant materials are, however, difficult to compare directly with those of resistant materials. They are defined and tested quite differently.

Characteristics and properties

When considering the characteristics and properties of a fabric, the structure, physical form and chemical components of the fibre, the method and tension of twist in the yarn, and the construction of the fabric will all have an effect on the characteristics of that fabric and how it responds in different situations.

For example, woollen **fibres** have a scale-like structure and are usually crimped. These characteristics contribute to the thermal insulating property (when the fibres are processed into fabric, the unevenness of the fibre creates little air pockets). Cotton has an uneven and twisted fibre that does not reflect light easily, so it has a low sheen. Most silk and most synthetic fibres have a regular and smooth surface. They reflect light, and therefore have a higher level of sheen.

fibre
very fine, hair-like filament that can be spun into thread or yarn

Yarn is traditionally made from fibre. The characteristics of yarns depend on the type of fibre and the physical structure of the yarn – the direction of twist, the amount of twist, and the number and twist direction of the threads that form the yarn. The blending of different fibres in a yarn will also change its properties. For example, blending a small amount of lycra with cotton gives it more elasticity, while blending a natural fibre with a metal will add a stiffness.

yarn
thread, cord or rope spun from twisted fibres

Cloth fabric is traditionally made from yarn or thread, though some types of cloth, such as felt, are made from fibre. The characteristics and properties of a fabric relate to the type of fibre used and the construction of the fabric – whether it is woven, knitted or felted, whether it is densely or loosely constructed, and whether layers are laminated or bonded to form the fabric. The way a fabric is finished will also affect its properties. For example, the brushing of a fabric will increase its ability to insulate.

Note that there is a lot of overlap between characteristics and properties, and the terms are sometimes used interchangeably. These terms have specific definitions in some technical fields. However, in this study we usually group them together for ease of understanding.

9780170400336

Strength

Strength usually relates to the ability of the fibre, yarn or fabric to withstand tension without breaking. The strength of some fibres changes when wet – e.g. wool loses strength and cotton gains strength when wet.

Durability

Durability is a more general property that takes into account the material's strength, elasticity and resilience. The level of durability will indicate how the fabric will withstand everyday wear and tear. A fabric's durability may be tested by repeated washing and/or through **abrasion testing**.

abrasion test test of a fabric's durability, performed by rubbing it with an abrasive, such as sandpaper or a hardened metal surface

Elasticity

Elasticity is the ability of a fibre, yarn or fabric to stretch without breaking, and also its 'stretch recovery' – whether the material returns to its original shape after stretching. Elasticity of fibre usually affects its 'wrinkle recovery' – whether it stays creased after crushing or appears 'uncreased' – and its ability to retain shape. Wool, for example, has elasticity, retains its shape and has good wrinkle recovery. Elasticity in fabric is also important for comfort and fit.

Moisture absorbency

Moisture absorbency relates to how much water is absorbed by the fibre, yarn or fabric. When considering absorbency, the terms 'hydrophilic' (water-loving) and 'hydrophobic' (water-hating) are often used. Fabric construction and surface finishes may affect the

Getty Images/FatCamera

Some sports clothing is made from absorbent material, such as cotton, for comfort; these uniforms are made from synthetics to wick moisture away from the body

ability of a fabric to absorb or repel water. The ability of a fabric to dry quickly may also be related to its level of absorbency, e.g. cotton absorbs moisture and takes a comparatively long time to dry.

It is important to think about comfort when analysing absorbency, as some fabrics may absorb much moisture but feel cold and clammy next to the skin (e.g. cotton), whereas others will absorb moisture well but still feel warm (e.g. wool).

Wicking

A moisture-wicking fabric allows moisture to travel easily from the inner to the outer surface of the fabric. Such fabrics are often used in activewear or sportswear as the fibre and fabric structure draws moisture away from the body to the outer surface of the clothing, where it can evaporate quickly and easily.

Thermal properties

Thermal properties refer to the ability of a fibre, yarn or fabric to insulate against, or conduct, heat or cold. If a fabric is a good thermal insulator, then it will keep the body at a regular temperature and will not be affected by outside conditions. If a fabric is a good thermal conductor, it will allow the body to heat or cool quickly according to the outside temperature.

Shutterstock.com/Getmilitaryphotos

Good thermal insulators keep the body at a regular temperature

Reaction to chemicals

Some fabrics, fibres and yarns have adverse reactions to different forms of chemicals, such as acids, alkalis and bleaches. Understanding the effect of these chemicals on a material may determine how it should be treated and washed. For example, wool is not affected by acids but is weakened by alkalis and bleaches, and therefore should be washed with specially formulated soap, and not bleached. Conversely, cotton is resistant to alkalis but is weakened greatly by acids.

Effects of sunlight

Some fabrics, fibres and yarns are greatly weakened by prolonged exposure to sunlight. Understanding these effects is important, particularly when making choices about materials that are used outside.

UV protection

Related to sunlight, the level of protection against ultraviolet (UV) light may be determined by the fibre

Shutterstock.com/Stephen Denness

Children's beach clothing should give a high level of UV protection

9780170400336

(some fibres are naturally protective, or may have additives included in processing), the construction of the fabric (its density) or a finishing process (a protective coating may be added to the fabric surface).

Resistance to biological attack

Fungi, mildew and cloth moths may damage some materials, whereas others are resistant. An understanding of this is important when making choices of material for a product used in humid, damp conditions, or when considering how to treat clothing for storage. Bamboo fibre is thought to have this resistance.

Shutterstock.com/Paul Prescott

Some natural fibres will easily absorb a range of dyes

Ability to take and retain dye

Different fibres absorb and retain dyes in different ways. Some natural fibres will absorb a range of dyes, whereas others – such as flax – cannot be dyed without weakening the fibre. Generally, hydrophilic (water-loving) fibres can be easily dyed. Many synthetic fibres that are hydrophobic (water-repelling) may need to have the colour added during fibre production.

Shrinkage

Shrinkage happens when a fibre, yarn or fabric becomes smaller after washing. The washing temperature and washing solutions may affect the level of shrinkage.

There are a number of forms of shrinkage:

- relaxation shrinkage – for fabric that springs back after the tension used in weaving or knitting is released
- felting shrinkage – for wool and hair fibres, if they become interlocked during rough washing in hot water; this is a permanent shrinkage
- consolidation shrinkage – for fabrics that are washed and then tumble-dried (particularly loose-knitted cotton), but regain their size after use
- hygral expansion – for fibres (especially wool) that expand as they absorb moisture, and shrink as they lose moisture and dry out; a reversible shrinkage.

Shuttestock.com/Luba V Nel

Fabric that drapes well falls softly over forms

Drape

This term refers to the flexibility of a fabric – how it falls and folds. Drape is determined by both the stiffness/elasticity of the fibre, and the density/weight of the fabric construction. If a fabric is said to drape well, it falls softly over forms, is flexible and folds easily.

Wrinkle resistance/recovery

Wrinkle resistance relates to the elasticity of a fibre. If a fibre is elastic (i.e. it bends and returns to shape), then fabric made from it is less likely to be affected by handling. Some fibres become more elastic (e.g. wool) and others less elastic (e.g. cotton) when wet. This means that cotton fabrics need to be handled appropriately to reduce washing wrinkles. The plasticity of a fibre (its ability to be moulded and changed) may also affect its wrinkle resistance and recovery. A fibre that is considered 'plastic' (e.g. silk) can wrinkle severely, but can be easily returned to its wrinkle-free state.

Testing for properties: important considerations

Many of the properties discussed above may be affected by the characteristics of the fibre, yarn or fabric. When comparing the properties of different fabrics, it is important to distinguish what aspect is affected or changed by the fibre content, what is affected by the twist or tension of the yarn/thread, and what is determined by the density or form of construction.

When testing fabric samples for a certain property, it is important that only one aspect of the samples is different (the fibre, the yarn construction or the fabric construction). For example, if a test measures fibre elasticity, it is crucial that the construction of the different fabric samples is very similar, as different types of fabric construction also have different levels of elasticity. It would, for instance, be inappropriate to test a woven woollen sample, such as gabardine, with a knitted cotton sample, such as T-shirt fabric.

MATERIALS TESTING: ALL MATERIALS

The reliability of all products depends on the quality and appropriateness of the materials used in their production. Thorough testing will help you choose the best and most appropriate materials. However, testing is only of use if the test procedure is consistent, well planned, repeated and accurately measured. You must also ensure that you collect and record your results accurately, and, of course, follow all safety procedures.

Elements of successful testing

Consistency

The most critical aspect of designing a materials test is to isolate the element that is being tested. It is vital that the only thing that changes in a test is the focus of the test – you must make sure that all other aspects of the test remain the same. Your testing procedure needs to be consistent and controlled so that it can be repeated for each comparative test.

For example, if you are comparing the moisture absorbency of two materials, you need to make sure the only thing that changes in your test is the material samples. There are factors that may have an impact on your results, including:

- atmospheric conditions (e.g. the weather, ventilation and direct sunshine)
- quantity of moisture used
- method of applying moisture
- size of material sample
- inaccurate or inconsistent testing equipment.

You need to control these factors as much as possible. The factors that may affect a test will change, depending on the nature of the test.

9780170400336

Planning

Plan your test carefully. If possible, trial a number of set-ups for your test to find the most accurate and effectively controlled procedure. Make a list of the equipment you will need and draw or photograph the equipment set-up.

Repeatability

You need to be able to repeat your test a number of times for each material. In this way, you will be able to check that your results are reliable (and not a one-off fluke), and you can also average your results over a number of tests to give a clearer indication of the performance of each material. When devising a test, it is important that the test conditions can be carefully controlled and set up in precisely the same manner for each test.

Accurate measuring

It is important to devise tests that give you objective results that can be measured or quantified (using numbers). In this way, you can easily compare the performance of your tested materials. Use the most sophisticated and accurate measuring equipment that you can access (talk to your science and technology teachers), making sure that it is appropriate for the measurements you wish to record.

Record results

Make sure you collect and record your results in a methodical way. This will help you to easily see the differences between your results. Good record keeping will also help you to present your findings clearly in your report.

Remember to record any other observations you make during the test. Your test samples may change in ways you don't expect.

Safety

Make sure that your test procedure is safe and that you don't put yourself and others at risk. Some tests may need to be checked by an expert/teacher to ensure that there are no dangers of which you are unaware. Areas that may cause problems are tests that involve heat, flames, chemicals, heavy weights, pressure, or the destruction of samples. Also make sure that there is limited risk to the equipment being used or the surrounding environment.

If you are performing a test that includes some risk, take appropriate and adequate safety precautions (e.g. use gloves and/or safety glasses, ensure there is adequate ventilation, have fire blankets or extinguishers).

Materials test report

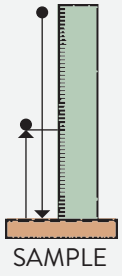
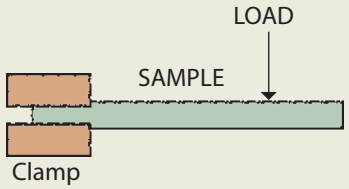
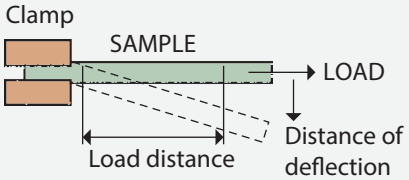
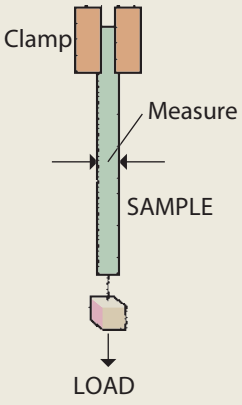
The following elements need to be included in an effective materials test report:

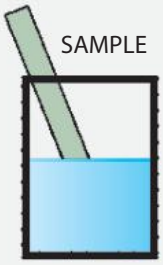
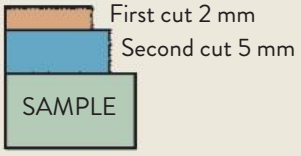
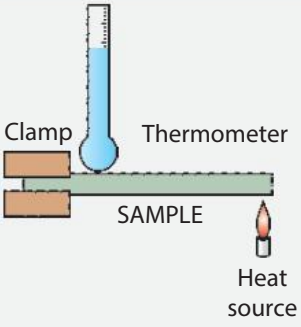
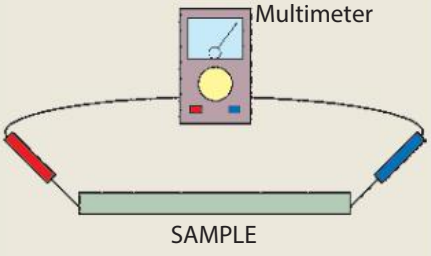
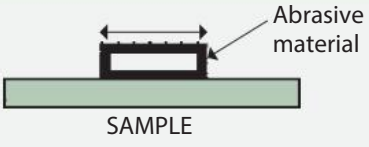
1 The characteristic or property being tested and the materials included in the test
2 Reasons for testing – explain the context or use of the information gained from the test ('How does this property relate to the product?')
3 A prediction of results – based on your knowledge of the properties of the materials to be tested
4 Testing procedure – step by step

9780170400336

5 A diagram/photo of the testing set-up
6 Numerical results – in table and graph form
7 Observations – in writing
8 Analysis and interpretation of results ('What do the figures tell us about these materials?' 'Do the test results differ from your predictions or expectations?')
9 Consequences for material use ('How will this affect the decisions you make about the use of these materials?')
10 An evaluation of the testing procedure ('Was this an accurate test?' 'How could it be improved?' 'What sort of equipment would improve the accuracy of your results?' 'How might the test be carried out in industry or in scientific laboratories?').

Tests for resistant materials

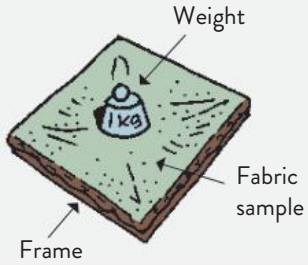
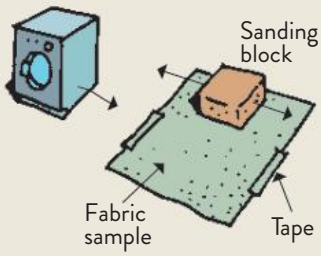
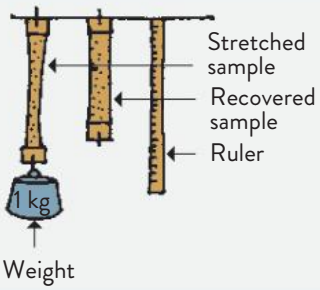
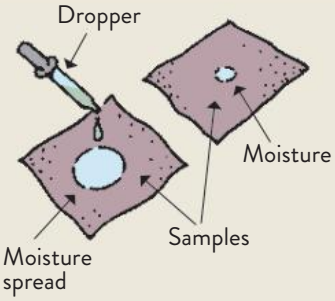
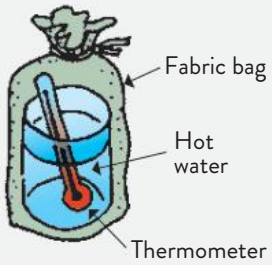
Property	Description of test	Diagram
Hardness	Drop a 12 mm ball bearing from a specified height (e.g. 300 mm), and compare the size of indentation and measure the height the ball rebounds. Harder surfaces will rebound further and not mark from the impact. Or do a scratch test. Gather a series of material samples. Scratch one against each of the others. The material that marks the other sample is harder than it. Rank the samples from softest to hardest.	
Strength and durability	Hang a load from the material sample, increasing the load until failure occurs. Measure the weight required to break the sample.	
Elasticity	Subject the material sample to loading until it bends. Release the load and check to see if the sample returns to its original position, or measure the distance from its original position (you will need a reference point to measure from).	
Ductility	Accurately measure the diameter or cross-section of the sample and apply a working load (tensile force). Release the load and remeasure the diameter or cross-section area to determine if it is thinner (appropriate for metals). This test will only give tiny changes – very accurate measuring equipment is required.	

Property	Description of test	Diagram
Corrosion resistance	Place a material sample in the intended work environment (e.g. water, boiled water, water with salt, washing powder, vinegar) and observe over an extended period of time. Note the degree of degradation (rate change of colour, surface damage, etc.).	
Ease of machining	Place a material sample in the selected machine (e.g. lathe, milling machine, router). Starting with a shallow cut, increase the depth on successive cuts and note the ease or difficulty the machine has in cutting through the depth. Note observations – effort required, sound of machinery while cutting, difficulties due to material variation, etc. (This test doesn't give easily measurable objective results.)	
Thermal conductivity	Attach a thermometer to one end of the sample material and note the rise in temperature when the other end is heated for a specified time. The thermometer should always be the same distance from the heat source, and the heat source should be at a constant temperature.	
Electrical conductivity	Obtain a multimeter and set it to ohms or resistance scale. Place one probe at each end of your sample. Materials that are conductive will give a reading while non-conductors will not.	
Wear resistance	Take a sample of the material and subject it to continuous contact and movement from the types of surfaces it will experience when in use. Count the number of movements until the sample starts to show wear, or observe the wear compared with an untouched sample.	

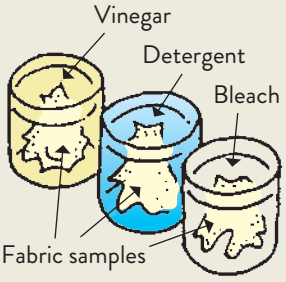
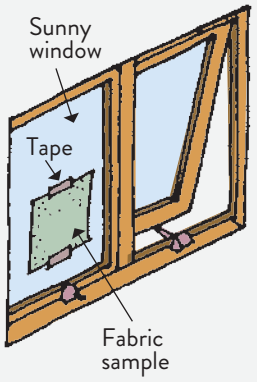
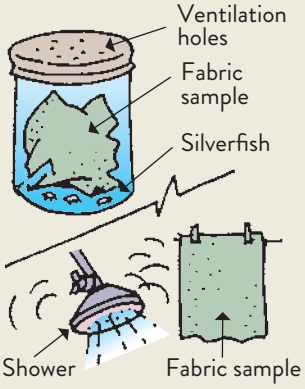
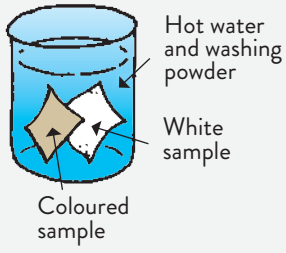
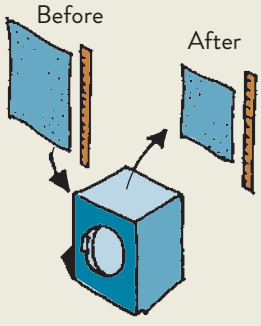
Some of these tests are more suitable for one material area than others (e.g. hardness for timber, thermal conductivity for metals, etc.)

9780170400336

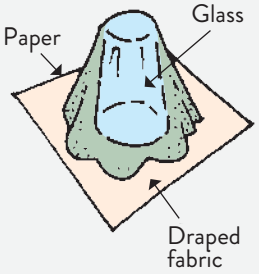
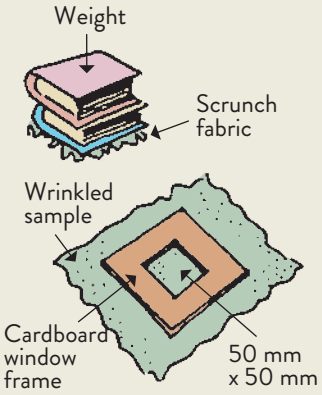
Tests for non-resistant materials

Property	Description of test	Diagram
Strength	Attach a fabric sample to a wooden frame (carefully plan the method of attachment so that this doesn't damage material or tear during testing). Load the sample with weights, and measure the weight needed to tear or damage the fabric.	
Durability	Repeatedly wash fabric samples, noting shape change, size, colour change and strength (do simple strength tests). Abrasion tests can also be done (e.g. rubbing surface with sandpaper block).	
Elasticity	Fibre – measure how far a fibre will stretch before it breaks (start with fibres of the same length). This is a very delicate test, requiring care. Fabric – attach a weight to a sample fabric strip and record distance of stretch. Measure fabric after weight is removed to record level of recovery. (Choose a weight that will stretch but not tear or break the fabric samples.)	
Moisture absorbency	Either drip a controlled amount of water onto a fabric sample and measure the spread of moisture, or dip the ends of fabric samples into water and measure how far the moisture travels.	
Thermal insulation	Completely cover a beaker of hot water (containing a thermometer) with a fabric 'bag' tied tightly. At regular spaces of time, record the temperature change in the water.	

9780170400336

Property	Description of test	Diagram
Reaction to chemicals (acids, alkalis, bleaches)	Submerge fabric samples in dilute forms of acid (e.g. vinegar, lemon juice), alkali (detergent) or bleach. Remove after a length of time and test for strength.	
Effects of sunlight	Leave fabric samples in direct sunlight over an extended period of time (e.g. two weeks). Record observations of changes in the fabric (e.g. colour) and test for strength.	
Resistance to biological attack	Insects – collect cloth moths and/or silverfish and trap with samples in jar (with ventilation). Record the amount of holes (if any) after defined periods of time. Fungi and mildew – leave samples in an appropriate place (bathroom) for an extended period of time. Record level of fungal/ mildew growth.	
Ability to take and retain dye	Place samples in dye and record level of dye intake (devise a 1–10 grading system). Use a range of different dyes and colouring agents. Colour fastness can be tested by washing a sample with another sample of white-coloured absorbent fabric and recording the level of colour that is transferred.	
Shrinkage	Measure and precisely cut samples. Wash and record changes in size. (Large samples show greater change of size and are easier to measure.) Repeat tests with different water temperatures.	

9780170400336

Property	Description of test	Diagram
Drape	Place a large circle of fabric over a glass and trace the shape of the fall of cloth (fabric circle diameter = 2 × glass height + glass diameter). The greater number of folds and the smaller the shape, the softer the drape.	
Wrinkle resistance/ recovery	Scrunch fabric into a ball and place a weight on it for a set period of time (this can be done wet or dry). Unfold, and record the number of folds/creases in a small section (use a cardboard frame with inner measurements of 50 mm × 50 mm). Rate the depth of creases (shallow, medium, deep). Hang samples for a set time and record level of recovery. Iron samples at cool, medium and high heat (if appropriate for fibre) and record recovery.	

Shutterstock.com/guruXOX

CHAPTER 7 Resistant materials and processes

CHAPTER FOCUS

In this chapter you will learn about the origins, properties and processing of:

- Wood p. 158
- Metal p. 181
- Plastics p. 194

and the processes used to work with them.

Through case studies (p. 203), you will also discover how designers work with these materials.

WOOD

Origins and properties

The unique characteristics of wood have made it one of the most widely used construction materials throughout history. It has been used successfully to build housing, boats, bridges, furniture, vehicles and all manner of tools and utensils.

General properties of wood

Many of wood's physical properties are dependent on its moisture content. Seasoned timber is a good thermal and electrical insulator, and is stronger in tension and compression than when subjected to shear forces. Wood is combustible and suffers from biological attack, however, some timbers have antibacterial properties. *To revise forces and properties, go to pages 142–47.*

Timber classification

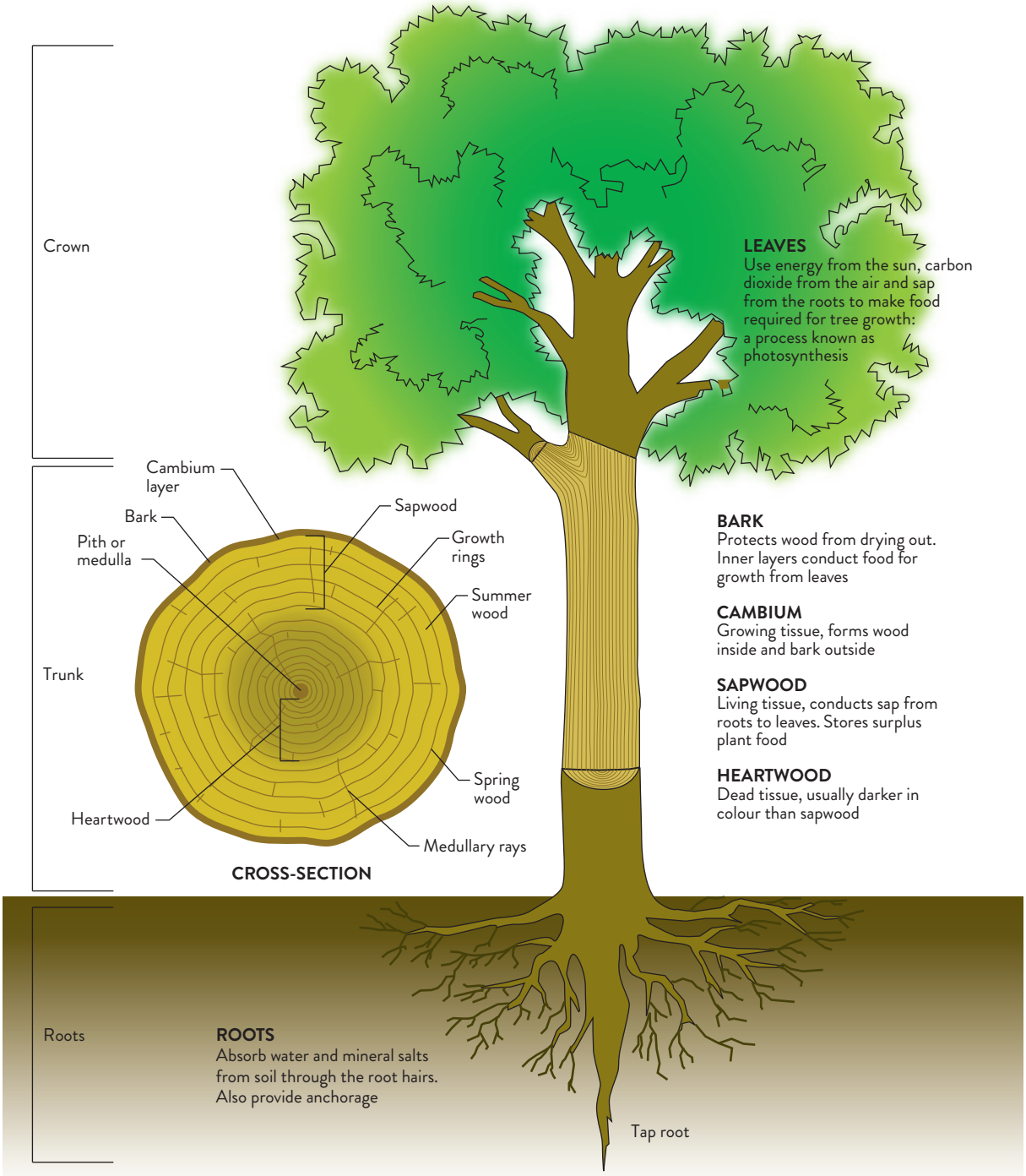
Timber is classified according to its botanical features as either hardwood or softwood.

Hardwoods come from trees with leaves. There is a general misconception that the term means these timbers are 'harder' than softwoods. Many hardwoods are fairly strong and dense, but the group also contains such timbers as balsa wood. The term 'hardwood' relates to a group of trees that have a common cell and growth structure. Their structure is characterised by large tube-like vessels or pores consisting of short cells that conduct fluids from the roots to the

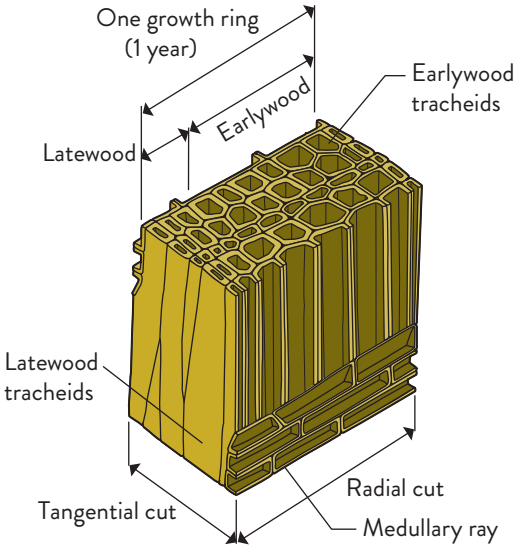
9780170400336

leaves. Smaller, thick-walled cells or fibres provide mechanical support for the tree. Hardwoods usually have broad leaves, flowers and fruit.

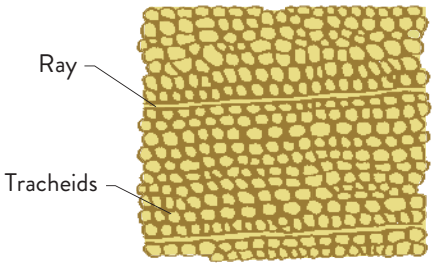
Softwoods come from trees with needle-like foliage and cones, and have a simpler, more uniform cell structure than hardwoods. They consist mostly of long, thin cells called tracheids, which provide mechanical support for the tree and conduct fluid from the roots to the crown. Pits or tiny holes in adjacent cell walls connect the tracheids.



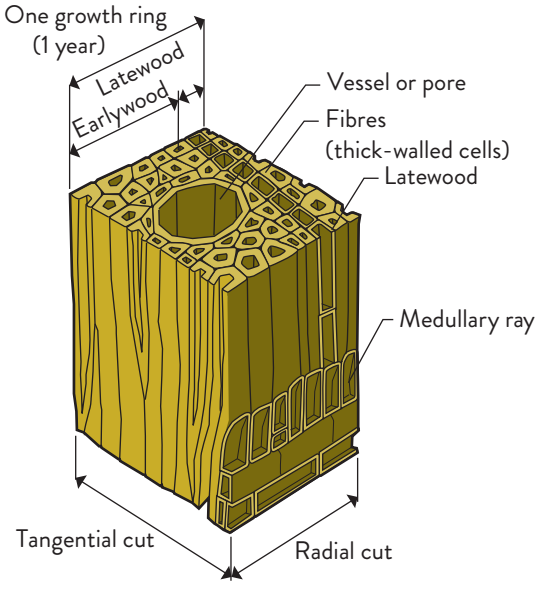
The structure and cross-section of a tree



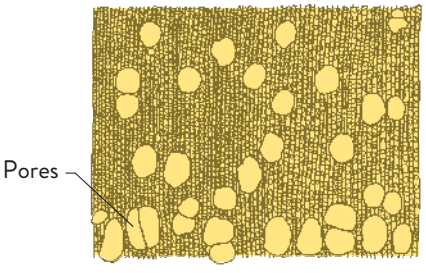
Cell structure of softwood (non-pored)



Cross-section of softwood



Cell structure of hardwood (pored)



Cross-section of hardwood

The differences between softwood and hardwood

Bamboo is a plant that is increasingly being used for furniture and other products. It is difficult to place when classifying timber as it is technically a grass.

Examples of commonly used hardwoods and softwoods

Hardwoods		Softwoods	
Balsa	Meranti	Cedar (excluding Australian red cedar)	Queensland kauri
Beech	Ramin	Cypress pine	Radiata pine
Blackwood	Redgum	Douglas fir	Redwood
Jarrah	Teak	Hoop pine	Rimu
Mahogany	Victorian ash or Tasmanian oak (eucalypt)	Huon pine	Spruce

9780170400336

Timber sources

Timber comes from two main sources:

- logging of natural forests
- plantations (tree farms).

Forest logging provides a variety of timber types, and the trees are usually older and more established. Trees sourced from a plantation are uniform in type and size, and are usually younger (30–80 years of age) than the major trees removed from forests. Most trees are removed from both forests and plantations using **clear felling** methods, which removes all vegetation from a coup (an area of trees).

clear felling
a logging method that clears an area of all vegetation

Timber production

Both hardwoods and softwoods are obtained and prepared for use by the processes of logging, milling (cutting from the log) and seasoning (drying). Seasoning removes moisture from the timber until it reaches a stable and usable level (when timber is logged, it has a high moisture content). This can be done either in the open air or in a kiln (kiln drying is faster, more controlled and more stable). Manufactured boards use the wood as the raw material, usually in veneer, chip or pulp form – these are processed to make new materials, usually in sheets, boards or moulded shapes.

Manufactured boards

There are manufactured timber materials that are made from wood pulp, chips, glue and/or veneer. They come in various thicknesses, textures and qualities, and are useful for constructing a wide range of products for different environments.

Commonly used manufactured boards include:

- medium density fibreboard (MDF) and highly moisture resistant (HMR) fibreboard – made from finely processed timber fibres bound with glue
- chipboard or particle board – made from larger timber chips
- masonite (a hardboard) – also made from finely processed timber fibres processed with high-pressure steam, and without glue or binder
- plywood – made from thin layers of timber veneer, with the grain of each layer turned at 90 degrees and crossed. It is very strong for its weight and versatile.

A thin layer of quality veneer is often used to cover the outside surface of manufactured boards. This conserves the highly valued timber and improves the appearance of the boards.

Moisture content and milling methods

Different trees have a different moisture content when they are newly cut down – radiata pine can have a moisture content of up to 180 per cent (there is more water in the cells than there is plant material in the cells), but trees such as cypress that grow in a drier climate may have a moisture content of only 45 per cent.

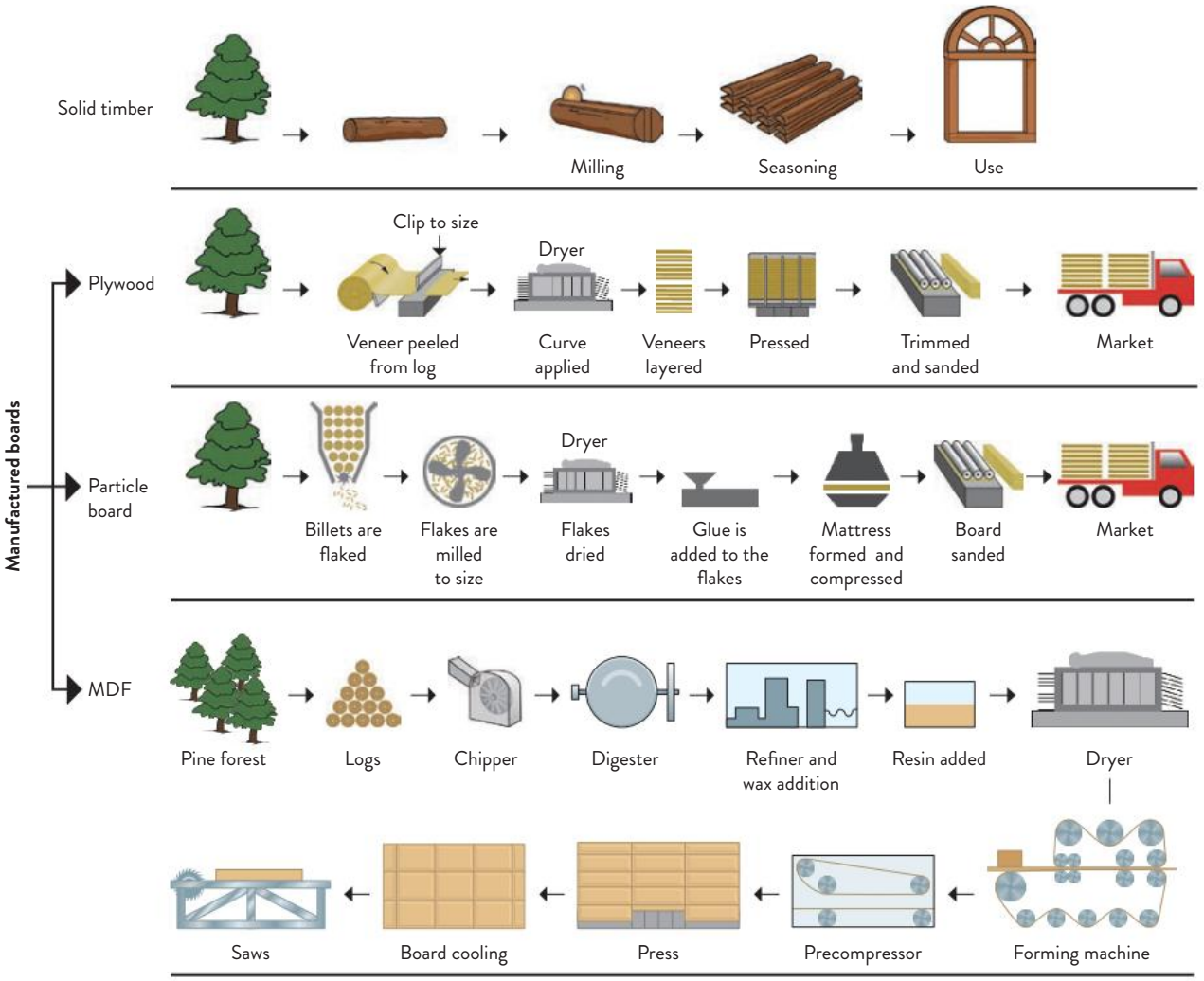
When timber is seasoned, it should have a moisture content of about 15 per cent. As the moisture evaporates, the cells shrink, which means that radiata pine will shrink a lot more than cypress.

For information about how moisture content is calculated (and other technical data sheets produced by Timber Queensland), go to the website of Queensland timber merchant Finlayson's, click 'Resources' and find Technical Data Sheet TDS 28 – Moisture in Timber. A link to the website has been provided at http://nelsonpdtvce.nelsonnet.com.au.

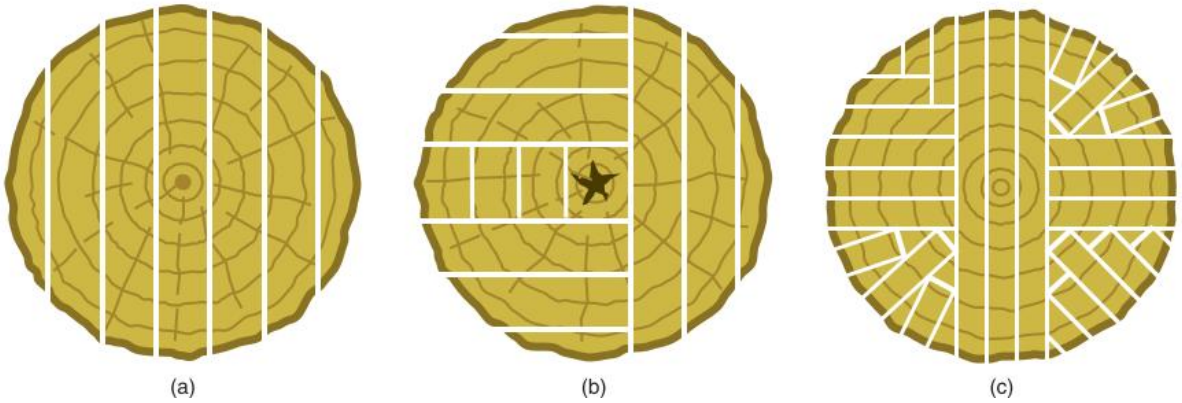
The way timber is milled also has an impact on how the timber moves and shrinks as it loses moisture. The cells in the outside layers of a tree have a higher moisture content and will shrink more. If a piece of timber is cut radially towards the centre of the log (quarter-sawn),

the part of timber that is furthest from the centre will narrow a little. However, if the timber is cut across the log (through, live or back sawn), the sides and ends closest to the outside will shrink more – cupping or warping the plank and causing more distortion.

Timber processing and production



A timber processing and production flow diagram



Different methods of sawing: (a) plain, through or live sawing, (b) back sawing, (c) quarter sawing

Common timbers and wood products

Types and forms	Name (origin)	Appearance	Properties	Uses
Softwoods, available in boards, beams and special mouldings	Pine – radiata (California, Mexico)	White to creamy yellow, prominent knots	Medium strength, works easily, takes preservatives and stains well	General construction, furniture
	Pine – white cypress (Australia)	Pale yellow to brown	Hard, firm grain, knotted, white ant–resistant	All building purposes, flooring
	Pine – hoop (Australia)	Very pale yellow	Very fine, straight grain	Furniture, veneer, plywood
	Western red cedar (North America)	Reddish brown	Soft but durable, easy to work	Window frames and doors, joinery, cladding
Hardwoods, available in boards, beams and special mouldings	Victorian ash/ Tasmanian oak (KD hardwood; Australia)	Light brown, hints of pink	Medium hardness	Furniture, flooring
	Balsa (Mexico, Bolivia, Brazil)	Light pinkish cream	Very light and soft	Modelling, prototypes
	Blackwood (Australia)	Brown	Strong and tough, excellent for steam bending	Furniture, cabinet work
	Box brush (Australia)	Light to red-brown	Hard and durable	Decking, construction
	Jarrah (Australia)	Rich red-brown	Hard, heavy and strong	Outdoor furniture
	Karri (Australia)	Yellow to brown	Hard, strong	Structural beams, furniture, flooring
	Meranti (also called lauan) (South-East to Central Asia)	Pink to pale red	Light, works easily	General purpose: construction, furniture, doors, etc.
	Teak (South-East to Central Asia)	Red-brown	Heavy, stable and strong	Outdoor furniture, decking, marine applications
Manufactured boards, available in various sheet sizes	Chipboard	Compressed chips or particles	Heavy and brittle	Flooring and large areas where low cost is important
	Coreboard	Laminated timber core with an outer sheet of ply	No shrinkage, heavy, easy to work and shape	Furniture, decking, doors, construction
	Hardboard (masonite)	Dark brown, compressed hardwood fibres, smooth on one side and textured on the other	No grain direction, easy to cut and bend	Wall and ceiling linings, mass-produced furniture
	MDF (medium density fibreboard)	Light brown sheets, fine fibres, often covered in veneer or laminate	Cuts and machines easily, produces a fine dust (hazardous)	General furniture, light construction, mouldings
	Plywood	Thin layers of timber laminated together with the grain at 90°	Strong, flexible, easy to shape and bend if thin	General construction, panelling
	Veneer	Very thin layer or sheet of timber (either a sectional cut or 'peeled' from the log)	Very fragile, visual appearance of solid timber	Used to cover chipboard or MDF, in the construction of plywood, or for laminating

9780170400336

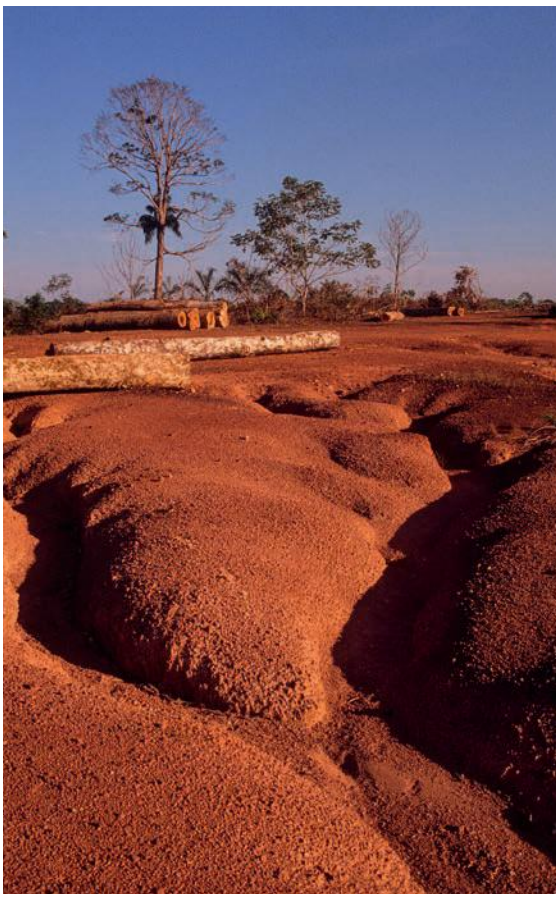
Health and safety issues related to wood

In its solid form, timber poses few if any dangers, apart from those that can occur through poor lifting and carrying procedures. Timber dust can be an irritant, and long-term exposure can cause sinus and respiratory health problems. A number of timbers can bring on an allergic reaction in some people, either in their nasal passages through the inhalation of dust, or on the surface of their hands through handling. Some of these people can become sensitised to particular timber types through exposure. Some chemicals used in treating timber can also be hazardous.

Of particular danger are manufactured boards that are made from wood fibres or chips bound with formaldehyde, such as medium density fibreboard (MDF). The dust caused by shaping and sanding MDF can be very harmful when inhaled. The fine particles are not filtered out by the respiratory system and can lodge in the lungs and initiate cancerous growths. **MDF should not be used in schools without highly efficient, industrial-level dust extraction.**

Machining operations on timber and its products pose hazards through the creation of dust and noise, along with the associated dangers of machine operation, such as flying debris and machine contact. Adequate ventilation, and eye and ear protection are vital.

Finally, the application of glues and finishes by spraying or other methods can create mist, vapour and fume hazards. Use appropriately filtered masks to counteract these problems. Instructions on safe use of finishes can be found on packaging and on a Safety Data Sheet (SDS) – this should be available in your school. Refer to pages 39–43 for details of risk assessment and identifying and controlling risks related to materials and machinery.



Auscape/Wayne Lawler

Erosion caused by land clearance

Quality of materials

Timber and timber products are graded for their strength, and their resistance to rot and moisture, as well as quality of grain or surface. Strength gradings for timber are specified in a range of Australian Standards. Materials receiving the highest ratings cost more but deliver superior levels of performance. Kiln-dried timber is usually more expensive than air-dried timber, but is more stable and less likely to warp. Some specialty timbers are very costly due to their unique characteristics, and because they are often difficult to source and process.

Environmental issues

The major environmental issue associated with timber is the logging of forests. Of particular concern is the destruction of complex and irreplaceable rainforest ecosystems through clear felling. Many of the timbers used in construction and furniture production come from rainforests in Asia (e.g. ramin, meranti, merbau and non-plantation teak) and South America. Rainforests take many hundreds of years to develop, and, once cut down, cannot be re-established. The logging of other types of forest is also of concern, as it reduces or removes habitats for native birds and animals. Clear-fell logging of any forest has a much more destructive impact than selective logging, causing the destruction of habitat and degradation of land. The removal of a stabilising root structure leads to the loss of topsoil and significant erosion, and a greater likelihood of flooding.

Plantation timber is usually a more environmentally sustainable option. However, plantations of species that are not native to the area of planting can be problematic. Often, the local flora and fauna cannot exist among these 'foreigners'. Even a plantation of a single type of native tree creates a disturbed environment where other plants, birds, animals and insects find existence difficult.

When selecting timbers that are more environmentally sustainable, it is critical to look for Forest Stewardship Council (FSC) certification – this means that the forest from which the timber is sourced is accredited as being sustainably managed. For more information about the accreditation process, go to the Forest Stewardship Council of Australia's website. A link has been provided at http://nelsonpdtvce.nelsonnet.com.au. *Refer to page 125 for information on environmental strategies relating to timber products.*

Look for the FSC logo on timber and furniture products made from sustainably managed forests.

Processes for timber

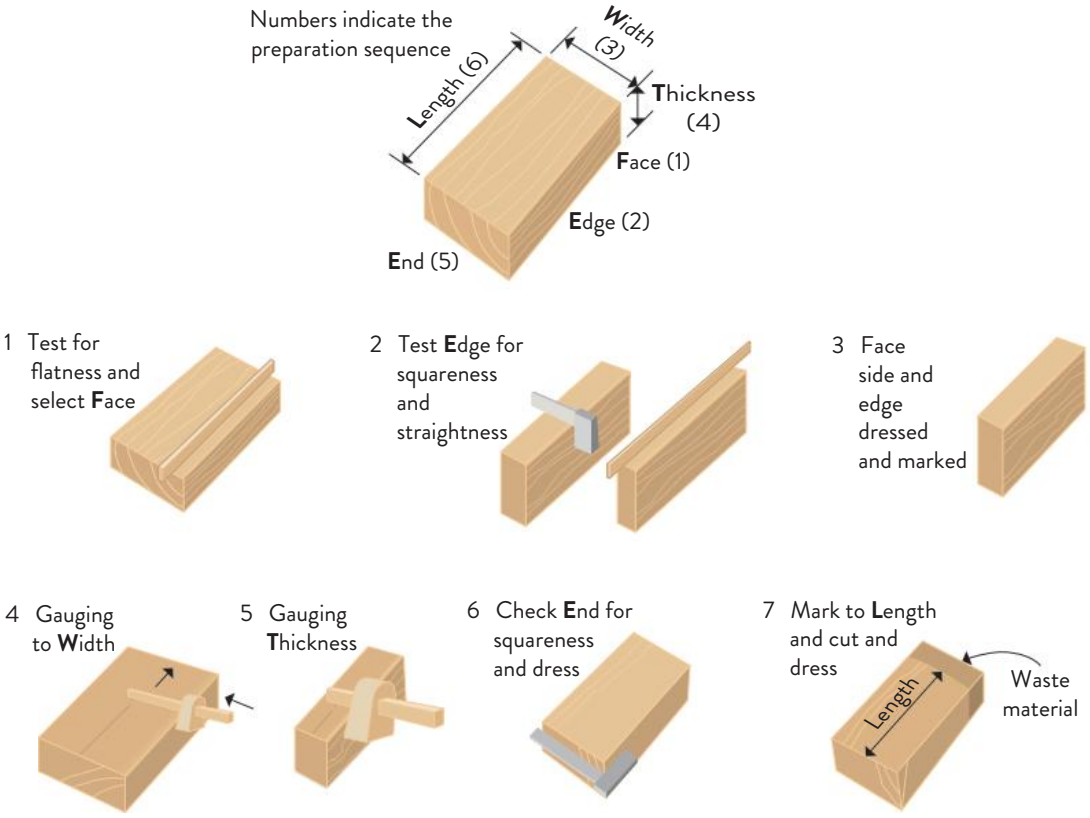
Timber preparation

Preparation is the first important step in ensuring that your design is manufactured to a high standard. Without square edges and flat surfaces, accurate marking out is impossible. Timber can be prepared using a hand plane or electrical powered device, such as a thicknesser. Whatever method you choose, ensure that accuracy is your first concern.

The mnemonic **FEWTEL** is often used to recall the order in which the preparation stages take place:

- **F**ace – prepare a flat face
- **E**dge – prepare an edge at 90°
- **W**idth – mark and trim to width
- **T**hickness – mark and reduce to thickness
- **E**nd – prepare one end square
- **L**ength – mark and cut to length.

Once timber has been correctly prepared, all other operations that follow should be accurate.



The mnemonic FEWTEL helps you remember the order of timber preparation

Measuring and marking tools

- Steel rule
- Tape measure
- Try square
- Combination square
- Sliding bevel
- Vernier tool
- Calipers

Cutting and shaping

Planing

A sharp, correctly adjusted plane quickly removes waste timber during preparation and when cleaning up for final finishing. An appropriate spoke shave or compass plane can be used on either inside or outside curves.

Portable power planes are frequently used in building and construction – these machines are extremely dangerous and are not recommended for student use.

Shutterstock.com/Marynchenko Oleksandr

A jack plane

In industry, timber is usually dressed or planed using either a planer-jointer (sometimes called a buzzer) or a thicknesser. Both the portable planer and the industrial thicknessers and planer/jointers have blades attached to a rapidly spinning cylindrical spindle (some recently developed planing cylinders use small square blades/teeth instead of long blades – producing a higher quality finish and reduced noise levels).

To use any planing machine, students need to be rigorously trained, tested and supervised, and must wear the required PPE, particularly glasses and hearing protection.

Sawing

Most sawing involves cutting straight along the grain (ripping) or across it (crosscutting).

Choosing the correct sawing tool will depend on the material being cut, the direction of the cut and whether the cut will be completed by hand or machine. Handsaws range from very large saws with big teeth that are used for cutting timber roughly along the grain, to small saws designed for particular purposes. Japanese saws are designed to complete the woodworking joins of that handcrafting tradition. There is a range of powered saws for different purposes:

- portable or smaller power saws:
  - scroll saw
  - jigsaw
  - multi-tool
- high-powered saws requiring specialist training:
  - drop/mitre saw
  - portable circular saw *
  - band saw *
  - table or panel saw *
  - vertical panel saw *
  - radial arm saw *.

*All of the machines marked with an asterisk are very hazardous – in most schools, students are not permitted to use them. They can only be used after rigorous training and competency testing, and under close supervision. The correct PPE must be worn. It is recommended that students find alternative methods of cutting.

9780170400336

Saw teeth for ripping are different from those for crosscutting – the shape and the set (the alternating angle) of the teeth are chosen to provide ease and accuracy in cutting either across, or along, the grain. Both operations require the timber to be held firmly so that it cannot move or vibrate during the cut. When ripping, it is possible that the timber will close around the saw blade and pinch it – this is particularly dangerous when using a circular or table saw. Most power saws are fitted with a **riving knife** to prevent this problem. When hand sawing, a thin timber wedge can be useful for maintaining the gap and keeping the saw blade free.

Shutterstock.com/Tyler Olson

A vertical panel saw

riving knife
a blunt blade that sits behind a saw blade for safety

Chiselling

Chisels are used to remove waste material from joints as they are being cut, or to clean up and make fine adjustments to joint structure. Most chiselling operations require the use of a mallet and it is usually necessary to saw-cut the join lines to break the fibres before chiselling.

Alamy Stock Photo/Zeljko Vala

Bevelled-edge chisels (left) and firmer chisels (right)

Lathe turning

Woodturning is carried out by spinning the timber at fast speeds **between centres**, on a faceplate or in a special **chuck**, depending on the object. Chisels and gouges are used to shape the timber, using either a cutting or scraping action. The angle of the blade of the chisel against the spinning timber is critical.

Faceplate turning is the best method for bowl shaping. It is done by attaching the timber blank to a flat plate that spins at the headstock. Hollowing is carried out with a gouge and the outside curve can be scraped or cut with gouges, scraping chisels or a skew chisel.

between centres
a spur drive and live or dead centres are used to hold each end of a long cylindrical blank (used for turning legs, balustrades, etc.)

chuck
a three- or four-part jaw that grips the turning blank

A timber lathe with parts labelled

9780170400336

Using routers

These portable power tools have spinning cutting bits. Router bits are shaped and sized differently depending on the cutting or shaping that needs to be completed. Some bits have roller ends that rest against the timber so that the shaping/cutting follows the timber's edge (used to cut laminates flush, or to create a decorative edge). Templates and guides can be used to cut joins or to create a pattern or design. Types of routers include:

- laminate cutter – a small, light router mainly used for trimming the edge of laminates flush with timber. It can also be used for shallow routed join cuts (e.g. rebates for plywood/glass insets in frames)
- plunge router – the blade of this tool has to be pushed down out of the router base when in use (giving the tool its name). It is used for larger and deeper cuts *
- inverted plunge router – as the name suggests, a router is turned upside down and attached to a specially designed work table. Instead of the router being moved along the wood, with this tool, the wood is moved across the exposed router bit. It is mainly used for edging smaller pieces of timber and cutting slots. *

CNC router

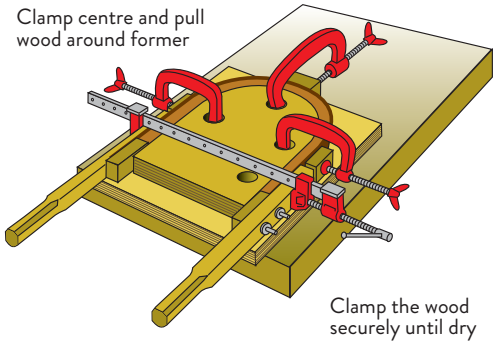
CNC stands for 'computer numerical control'. A CNC router uses computer-generated coordinate information on *x*, *y* and *z* axes to tell fine routing blades where to cut. An image of the required piece is developed in a CAD (computer-aided design) program and, after cutting, the result is a 3D cut object or piece. CNC routers have different driving machines compared to a CNC mill, and are used for machining softer materials such as timber and plastic.

Laminating and bending timber

Under the right conditions of heat and moisture content, timber is highly flexible. Most timbers can be easily shaped or bent with appropriate jigs and formers.

Bent timber has some unique physical properties, including its tendency to spring back after being flexed – which is highly desirable in many products, ranging from furniture to sporting equipment. The majority of these products are constructed from thin layers or laminations. These are bent around a former and glued together, giving a final and often complex shape that has strength and flexibility. Strength can be gained by placing the grain of consecutive layers at right angles, as with plywood, or in some cases laid diagonally to the expected lines of force, as they are in yacht construction.

Moulds for laminating veneers



Steam-bending

* These machines are hazardous. They can only be used after training, competency testing, and under close supervision. The correct PPE must be worn. It is recommended that students find alternative methods of shaping and cutting.

Common wood joints

Many different countries have developed their own traditional joining techniques. Hundreds of different joints are used around the world, but most come from one of three main categories:

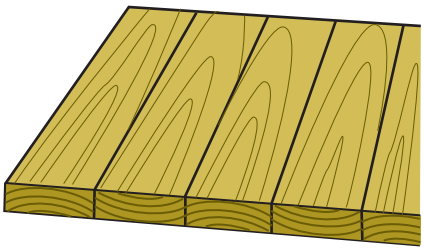
1 edge or widening joints
2 box, shelf and cabinet joints:
   - butt joints
   - rebate and housing joints
   - interlocking joints
   - mitre joints
3 framing joints:
   - mitre joints
   - halving joints
   - mortise and tenon joints.

Picking the right joint for your purpose is critical. Strength is the major concern, but appearance, your expertise and the available tools also require consideration. Poorly cut joints lack strength and reduce the quality of your finished product.

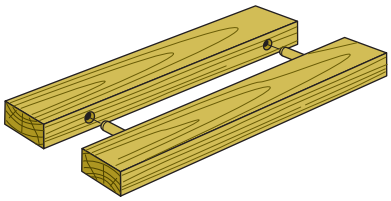
1 Edge or widening joints

Edge joints are suitable for creating large surfaces, such as tabletops. They are fairly strong because of the large gluing area. Straight and accurately prepared edges are essential; they should be done by a plane or jointer (sometimes called a surface planer or buzzer). Joints can be reinforced with dowels, dominoes or biscuits.

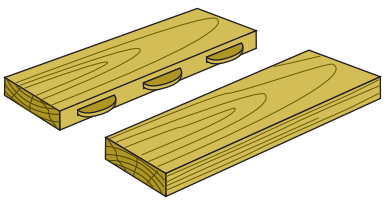
It is important to alternate the cupping/curvature of the boards when gluing, otherwise small cupping faults might be exaggerated (refer to the last diagram).



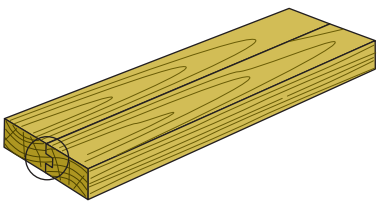
The edges of the boards show the use of alternate growth ring direction to cancel cupping



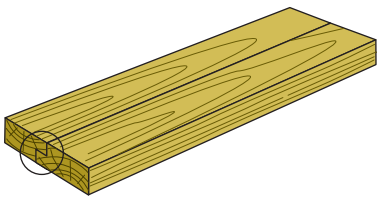
A dowelled widening joint



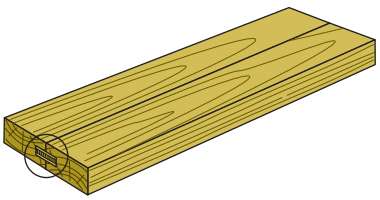
A biscuited widening joint



A tongue and groove widening joint



A rebated widening joint



Slip or loose tongue, using plywood or solid wood as the insert

9780170400336

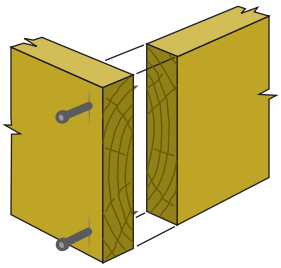
2 Box, shelf and cabinet joints

Butt joints

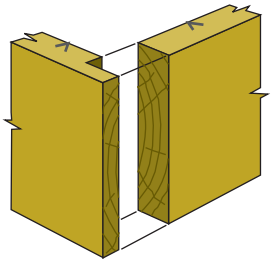
The butt joint is easy to construct and is suitable for rough carpentry. The ends can be cut using a power or hand saw and finished with a plane or jointer. This joint is structurally weak and is often reinforced with nails, dowels, biscuits or other fasteners.

Rebate and housing joints

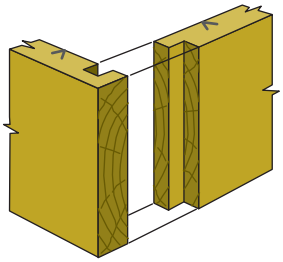
The rebate joint (also called the shoulder joint) is fairly strong and easy to construct using hand and power methods. It is suitable for the corners of boxes, drawers, cabinets and shelving.



A butt joint

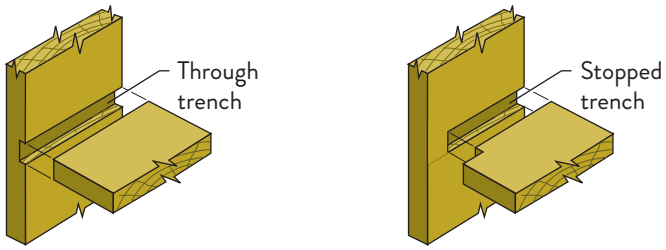


A rebate joint



A blind rebate joint

The housing joint (also called a **dado joint**) is usually done in a through, stopped or dovetail form. All are strong joints that are reasonably easy to construct with a router, table saw, or tenon saw and chisel. They are suitable for attaching drawer fronts, shelving, stairs and general cabinet construction.

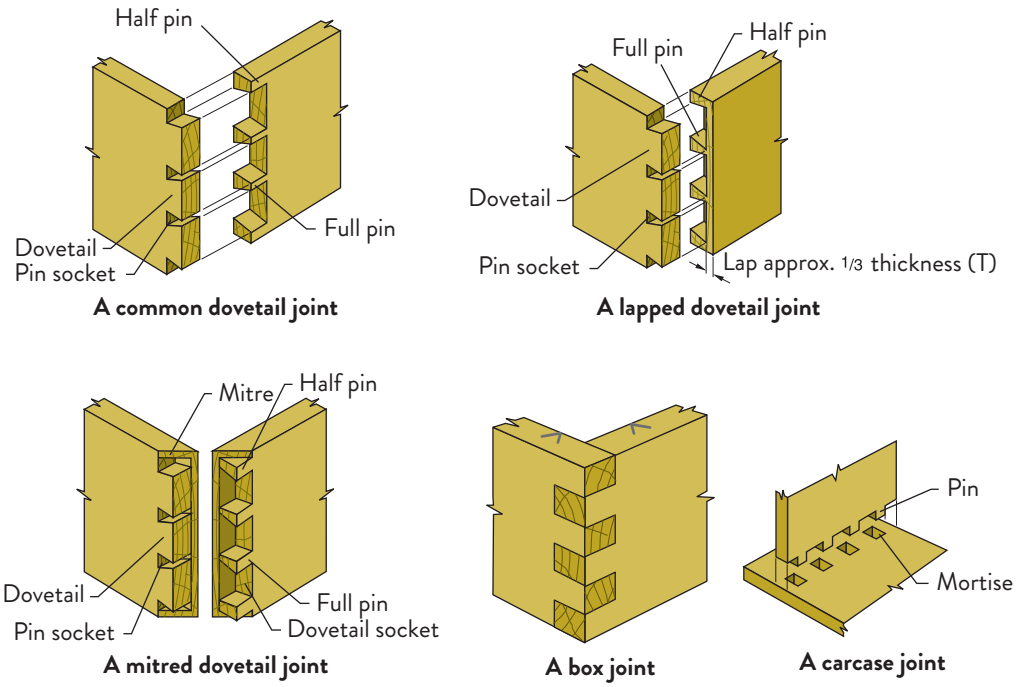


Housing joints

Interlocking joints

The dovetail joint and the box joint or pin joint are the most common interlocking joints. They are extremely strong and can be difficult to cut by hand. Dovetail jigs and routers have made accurate construction easier. They are used in drawers and boxes where strength is necessary.

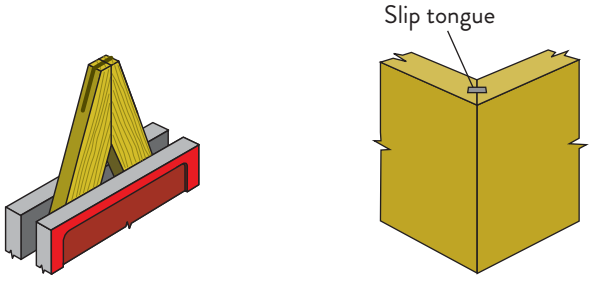
9780170400336



Interlocked joints

Mitre joints

The mitre joint is created in two common forms – the face mitre (for framing) and the edge mitre (for box construction). Both are structurally weak and suited to use in light applications, such as frames and mouldings. Dowels, splines, slips or fasteners are often used to increase their strength. Mitres are difficult to cut accurately by hand and require the use of a mitre box or power saw with an accurate angle-cutting facility.



An acute angled face mitre joint (note the spline for strengthening)

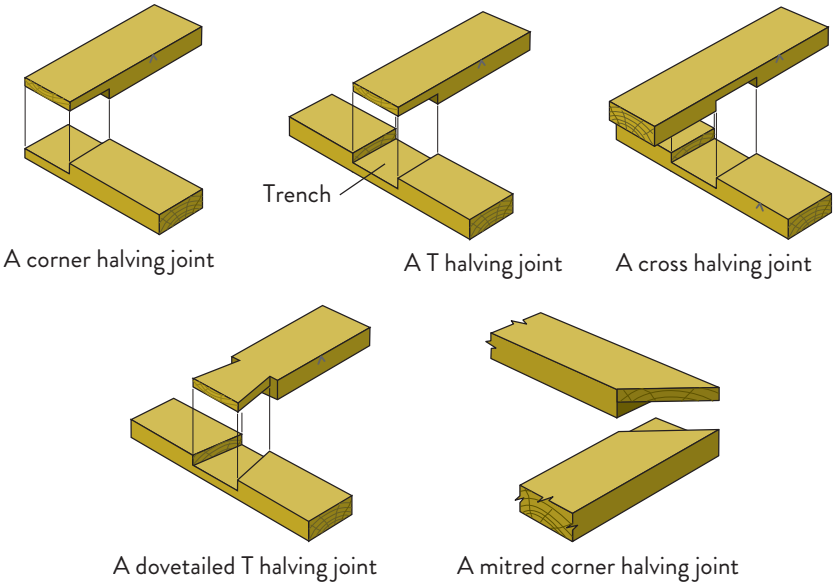
An edge mitre joint with a slip tongue

Mitre joints

3 Framing joints

Halving joints

The halving joint is strong and easy to construct with a tenon saw and chisel. Machine methods (such as the router, radial arm or table saw) are also suitable. Halving joints are mainly used for frames, panel doors and interlocking grid constructions.

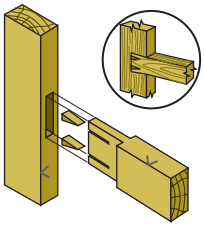


A corner halving joint
A T halving joint
A cross halving joint
A dovetailed T halving joint
A mitred corner halving joint

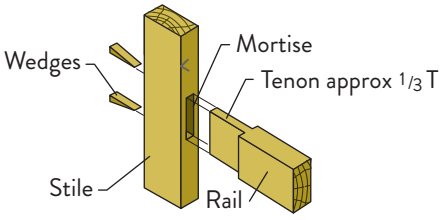
Halving joints

Mortise and tenon joints

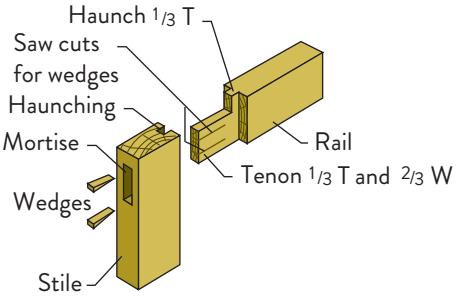
The mortise and tenon is a strong joint suitable for furniture and cabinet construction. It is reasonably difficult to cut accurately with hand tools. The tenon can be cut using a router, hand or power saw; and mortises can be drilled on a press or with a hand drill, and cleaned up with a chisel. Special-purpose mortise cutting drills and equipment are available, but these are not common in school workshops.



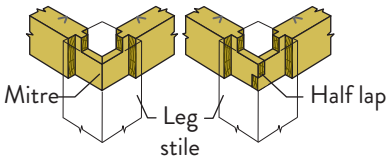
A sun mortise and tenon joint with foxtail wedging ready to insert in the tenon



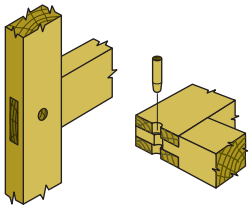
A common through mortise and tenon joint



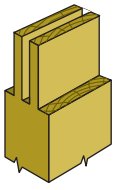
A through haunched mortise and tenon joint



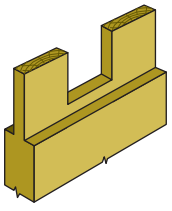
Alternative methods of making these joints in a table or stool construction



A pinned mortise and tenon joint



Twin tenons for a thick rail



A double tenon for a wide rail with a haunch between

Mortise and tenon joints

9780170400336

Assembly

Before gluing or any other form of permanent assembly, it is advisable to perform a **dry run** or **dry check**. The project should first be assembled without glue to ensure that everything fits correctly, and to work out the assembly procedure or order. Some glues 'go off' quickly, so assembly must be planned and completed efficiently (speedily). Collect all you need for assembly – materials, damp cloth, service timber, jigs, clamps, etc. – before you apply glue.

dry run
checking a joint for fit without glue

dry check
similar to a dry run

Gluing and clamping

When selecting an adhesive or glue, you need to determine the conditions under which it will be operating. Your considerations should include these factors:

- What are the materials being glued?
- Do the joints fit well?
- How much stress or pressure will be put on the joint when the product is used?
- Does it need to be waterproof? Is it for outdoor use?
- Is it being used for a product that has contact with food?

A guide to glue types

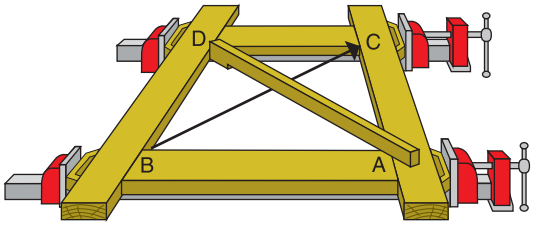
Glue	Assembly time	Clamping/ drying time	Uses	Characteristics
PVA white or yellow glue	7–10 min	8 h	• Indoors • Paper, wood, low-stress joins	• Dries clear and colourless • Water soluble
Polyurethane	45–60 min	2–3 h	• Boatbuilding, interior and exterior joinery • Timber, semi-porous and non-porous materials	• Moisture-curing, slightly foaming gap filler • Not visible in tight joins • Stains hands (use gloves)
Contact adhesive	• Can be moved while liquid for 10–20 min • Sticks on contact when touch dry	5 min	Universal adhesive: joins all materials	Viscous creamy liquid
Epoxy	Read label instructions	5 min – 12 h, depending on type of resin	Dissimilar and non-porous materials	• Toxic • Sets clear or brown • Mixed from liquids in equal ratios
Resorcinol	20 min	10 h at 21°C; longer if temperature is lower	Outdoor and marine	• Liquid mixed with powder • Dries dark red • Waterproof • Can be brittle
Casein glue	5–20 min	2–3 h	Indoor furniture, good for oily timbers	Powder mixed with water

No matter what your choice, some basic rules apply:

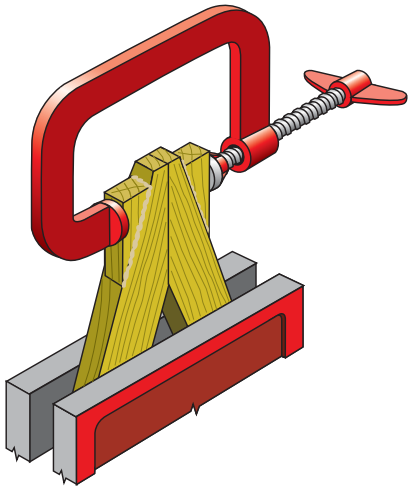
- The glue should be spread evenly, often over both surfaces.
- Some porous materials may require a pre-coating of glue.
- Clamps should always be fitted to apply even pressure.

9780170400336

- Joints must be checked for squareness (or the correct angle) and adjusted as needed before the glue dries.
- Some epoxy glues will not set below 18°C.
- Drying times will alter if the timber has a high moisture content, the weather is humid or the temperature is low.
- Always check instructions on any glue packaging for usage and any special safety procedures.

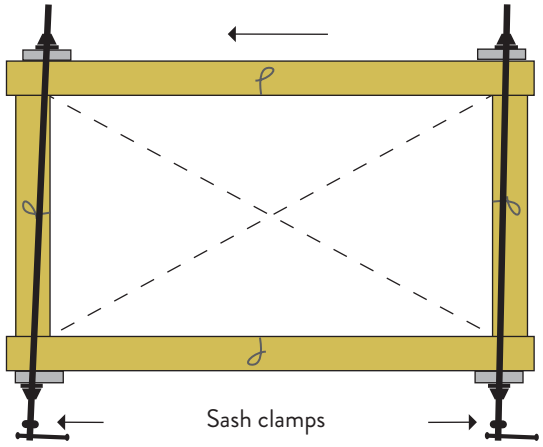


A diagonal stick compares the distances AD and BC; to square the frame, clamps are adjusted until the diagonals are equal



Blocks are glued to the edges of the joint with paper separators to allow the use of a G clamp

Assembly hints



The angles of clamps are adjusted to pull the frame square

Drills and drill bits

Tools used for creating holes in preparation for nailing, screwing and attaching components include:

- bench or pedestal drill
- horizontal drill
- portable drill (electric, either corded or portable; pneumatic)
- drill bits
- Forstner and spade bits
- hole saws
- dowelling jigs.

Shutterstock.com/Alexandr Makarov; Shutterstock.com/Alexiuz

A hole saw and Forstner bit

Biscuit or domino cutters

These are machines that cut indentations or shaped holes ready to receive biscuits or domino dowels.

Eye protection is essential when using all of these drilling and cutting machines.

Alamy Stock Photo/SoloStock Industrial

A biscuit joiner

Nail types and uses

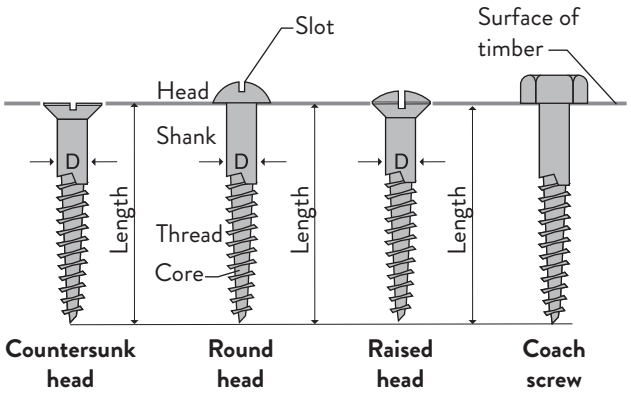
Nail type	Uses/sizes	
Bullet head	General construction, flooring, etc. mm: 25 × 1.4 – 150 × 5.6	
Bullet head: galvanised	External use, or where rusting is likely	
Flat head	Nailing thin timbers, packing crates mm: 19 × 1.25 – 100 × 2.5	
Panel pin	Fine joinery and mouldings mm: 13 × 0.9 – 50 × 1.6	
Clout	Fixing sheet metal and soft materials to timber mm: 13–38 × 2.4	
Twisted	Increased holding power – very secure mm: 64–100 × 2.7–3.8	
Brass escutcheon pin	Attaching small decorative hinges and catches mm: 8–30 × 1–2	
Cut tack	Attaching upholstery mm: 7–18 × 2–4	
Corrugated fastener	Reinforcing a weak join, rough work Various sizes	
Staple	Attaching wires or cables to timber Various shapes and sizes	

Andrew Kay Photography

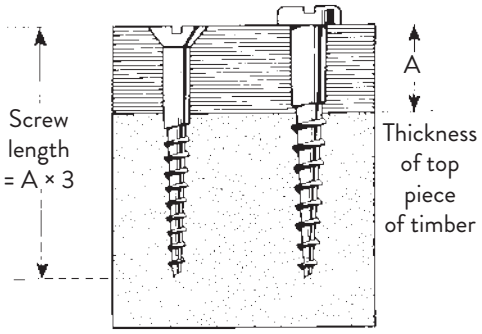
Screw types and uses

Screw type	Uses	Measurements
Countersunk head	Where appearance is not a concern and the head must finish flush with the surface Hinges and general work	Screws usually have two measurements: • one measurement that describes the weight of or diameter (D) of the screw (measured across the shank, just below the head) • another measurement that describes the length that sits below the surface The pitch of the thread is also sometimes given
Round head	Fixing thin metal or metal fittings	
Raised head	Decorative work, panelling, metal fittings Also used with cup washers to secure wall sheeting	
Coach screw	Securing light machinery, vices and gates	
Self-tapping screw	Securing particle board Has a drilling point and doesn't require pre-drilling	

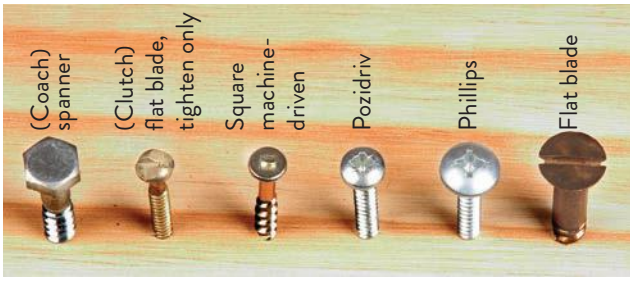
9780170400336



Details of screws – note that the 'length' is only that part of the screw that is inserted in the wood

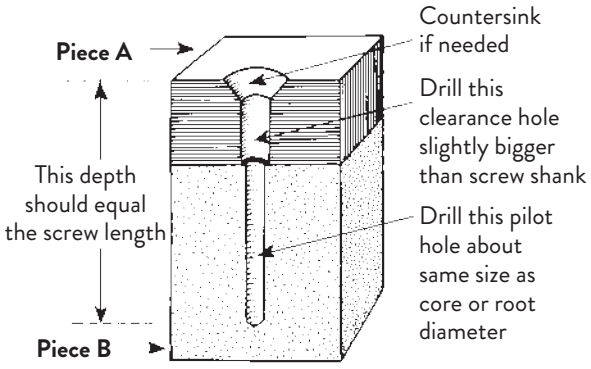


Selecting screw length



Andrew Kay Photography

A variety of screw-tightening methods



Pre-drilling for a screw

Assembly tools

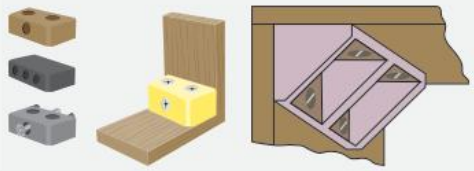
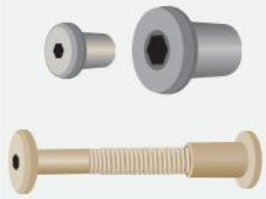
- Screwdrivers (hand, electric and pneumatic)
- Hammers and mallets
- Spanners and sockets

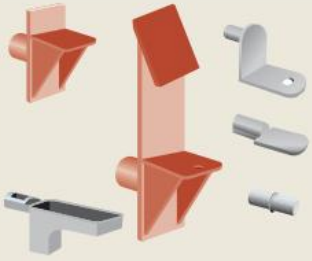
Clamping tools

- G clamps
- Quick-action clamps
- Spring or V clamp
- Web clamp
- Mitre clamp
- Sash cramps/clamps

Knock-down fittings

These types of fittings are used when products need to assembled and dismantled a number of times, or if the product needs to be flat-packed for transportation. Knock-down fittings are commonly used for mass-produced furniture that consumers assemble at home, and are often good to use in manufactured sheet material (they create a stronger joint and cause less splitting and fracturing). These fittings come in a wide variety of forms used for different purposes (*see table on following pages*).

Parts	Name	Purpose
	Connection blocks or rigid joiner	A range of different connectors available for joining parts at a 90° angle
	Furniture connection screw	These are easy to use in construction, and the deep thread means that they grip in particle board. Socket liners (caps) protect the material
	Furniture connection nuts and bolts	Parts that screw into each other without damaging the sheet material. Tightened with an Allen key
	Barrel nuts (cross dowel)	They sit within a drilled hole ready to receive a bolt – often used to connect parts at 90°
	Cam lock connections	These parts are used when a tight firm joint is required. The screwed connection is attached to the material and is then fitted into the large round cam: the joint can be tightened by turning the cam. Provides a hidden joint
	Tabletop connector	A receiving shape is cut into the underneath face of both sides of the join. The connector is placed in and the bolt is tightened to close the joint

Parts	Name	Purpose
	Bed fittings	Used to firmly attach the bed rails to the bed legs
	Shelf supports	Holes are drilled into the frame of the shelving unit to receive the supports. The shelves are then balanced on the supports. Drilling a series of holes allows the supports and the shelf to be repositioned
	Cover caps	These click into, and cover, the end of a screw; available in different colours to match construction material

Industrial tools and processes

- CAD/CAM driven lathe – can be computer-driven to consistently shape timber components
- CNC router – used to accurately cut and shape sheet materials
- Laser cutter – can accurately cut and engrave sheet material
- Steam press – to shape materials
- Nail gun – used in the building industry to pneumatically drive nails into a surface
- Industrial sander

Decorative processes

Carving

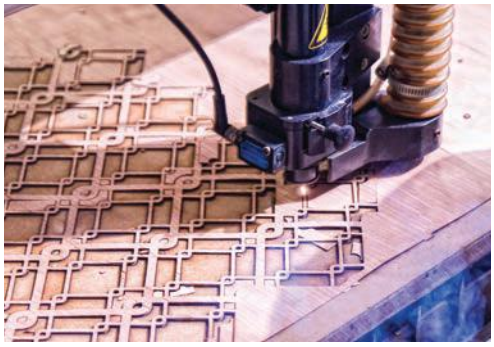
Special carving tools (chisels, gouges and electrical carving tools) can be used to cut into the surface of timber to create a decorative design. The backgrounds of some carved pieces are punched or embossed to create a patterned surface. Carving can also be done sculpturally, in three dimensions. There are a range of different carving techniques and traditions, but they all require precision, care and practice.

Dreamstime.com/© Mahantesh C Morabad

9780170400336

Fretwork: scroll or machine cut

Fretwork involves cutting through a thin layer of material to create a pattern of positive and negative shapes. This can be done by hand, using a scroll saw, or with a laser cutter.



Shutterstock.com/Rus S

Laser cutter

Engraving

Engraving is done in timber by marking the surface with shallow cuts to make a pattern, text or an image. This can be achieved by using a Dremel-type engraving tool, or with a laser cutter or CNC milling machine.

Marquetry

Very thin layers of timber veneer can be cut and inset into timber to create a pattern or image. This form of decoration effectively uses the subtle changes in timber colour and grain direction. Marquetry requires high levels of precision and skill, so it is important to start with simple forms and shapes when first attempting a pattern. You can find many useful video tutorials to help you learn this skill.

Shutterstock.com/alexcoolok

Stained or coloured patterns

Usually, stains are used to change the colour of a large section of timber, but they can also be used to add colour or tone in pattern work or in smaller sections. Stains tend to bleed into the fibres of the timber, so if only sections are to be coloured, the stain needs to be applied carefully. You can experiment with commercial timber stains, food colouring, or even coloured pencils, to add colour to timber before applying a clear finish. You can also transfer inkjet- or laser-printed images onto the surface of timber.

Finishing wood surfaces

Surface preparation

A quality finish will be enhanced if nails are punched and filled. Countersunk screws should be flush with the surface.

The majority of surface finishes you apply will magnify imperfections in the timber and faults in the preparation. For this reason, all visible surfaces should be in an absolutely smooth condition. Achieving this is usually done by sanding with the grain and using progressively finer grades of abrasive. Sanding blocks are preferred for handwork on flat surfaces. Hand sanding is rarely done on large areas; the availability of palm and random orbital sanders has made this arduous task much easier. These sanders are used with fine-grade abrasives to produce a smooth surface. It sometimes helps to dampen the surface to raise the timber fibres before the final sanding. An alternative method is to use a finely set plane followed by a cabinet scraper.

Selective use of power sanders and hand scrapers can greatly reduce the amount of hand sanding required, and will keep clean, sharp edges on the job.

Open-grained timbers will require the application of grain filler after sanding, to help obtain a high-gloss finish. The filler is applied across and with the grain by brush, and the excess is removed after drying by circular rubbing with a wad of cloth.

Applying stains

Stains are used to enhance the look of timber and to match it to existing furniture. Sometimes they are used to create a special effect, such as aging or surface texture. Stains are brushed or rubbed onto the surface and allowed to penetrate it, then the excess is wiped off, leaving a coloured surface.

Shutterstock.com/DJTaylor

Applying stain with a cloth

Another method of changing timber colour is through the use of a tinted finish. This colours the object with a layer on top of the timber surface, and each successive layer deepens the tone. Tinted finishes need to be applied very evenly.

Applying the finish

Surface finishes are applied to protect the timber's surface against marking and wear. The type and suitability of finish you choose will depend on the article's intended use.

Varnishes, lacquers and polyurethane coatings will build up a protective layer on the timber surface. Oil finishes, on the other hand, penetrate the surface and harden the timber's internal fibre structure. Lacquer and polyurethane are usually applied by brush or spray gun, while oil finishes are rubbed into the surface using cloth or a fine abrasive.

Finish types and uses

Finish	Surface effect	Method of application	Solvent	Uses
Polyurethane	• Durable matt or gloss finish	Brush or spray 2–3 coats	Mineral turpentine (turps)	• Heavy-wear areas and objects
Water-based varnish	• Durable built-up finish, matt or gloss	Brush 2–3 coats	Water	• Indoor uses • Environmentally safer than solvent-based • Can raise the grain
Oil-based varnish	• Durable built-up finish, matt or gloss	Brush 2–3 coats	Mineral turps	• General purpose • Marine uses
Synthetic lacquer	• Matt or gloss finish	Brush or spray 3+ coats	Lacquer thinners	• Mid-level protection
Shellac (French polish)	• Medium to high gloss • Can have different colours	Brush or paddle 3+ coats	Methylated spirits	• Low protection to water and heat
Tung oil (and other plant-based oils)	• Natural matt sheen • Enhances strong grain	Brush or wipe on 2–3 coats	Mineral turps	• Interior objects • No protection against abrasion
Danish oil	• Natural matt finish	Wipe on 3– 4 coats	Mineral turps	• Interior objects • Less protection than tung oil

9780170400336

Remember to check the instructions for application given on the finish's container. Care should be taken when using stains and finishes. Some are toxic and should only be used in well-ventilated areas. Flammable stains and finishes (solvent based) should be stored in an appropriate flammable materials cabinet.

METAL

Origins and properties

By comparison to other naturally occurring materials, metals have only been utilised by humans for a relatively short period of time. Gold, silver and copper were the first metals used by humans because they were reasonably available in their free state (i.e. they don't have to be processed much from their raw state to be useable). It is also possible that small quantities of iron from meteors were used. By about 3000 BCE, gold was being refined and worked into jewellery on a regular basis, and iron production was well established in Egypt and Syria by 1500 BCE.

Today, metals of all kinds have assumed an enormous importance in our lives. They are one of the most versatile and widely used groups of structural materials.

General properties of metals

Most metals appear in nature as ores and are greyish in colour when refined, except for bismuth, gold and copper. Their melting temperatures range from –39 °C for mercury to 3410 °C for tungsten.

Metals are generally strong and resistant to different types of stress, although there is considerable variation between metals. They are marked by properties such as hardness, tensile strength and some degree of elasticity. They can also be plastically deformed (bent) without breaking, and can be shaped and moulded when heated. Many are also prone to **corrosion** or chemical attack.

corrosion gradual destruction through oxidisation with moisture (rust) or the effects of other chemicals on the surface

Metal classification

Metals are divided into two major classifications based on their constituents: ferrous metals, which contain iron, and non-ferrous metals. Another commonly referred-to group of metals is alloys – these are simply mixtures of different ferrous and/or non-ferrous metals. Alloys often develop qualities quite different to those of their constituent metals, and are an extremely important area of metallurgical research.

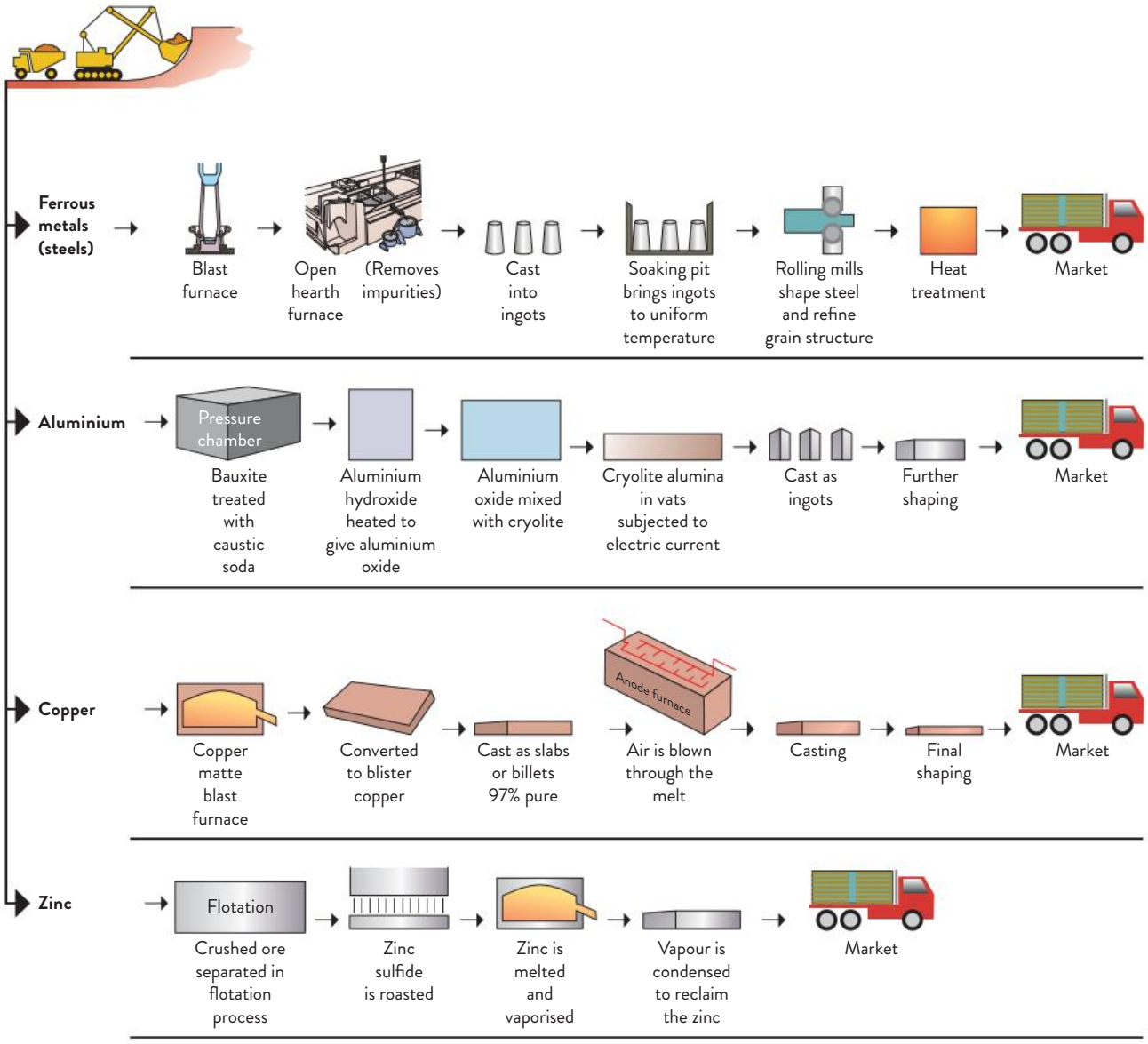
- Ferrous metals include the various types of iron.
- Ferrous alloys include the various types of steel, including stainless steel.
- Non-ferrous metals include aluminium, chromium, cobalt, copper, gold, lead, magnesium, nickel, platinum, silver, tin and zinc.
- Non-ferrous alloys include brass, bronze, britannia metal, cupronickel, monel metal, pewter and phosphor bronze.

Despite being prone to corrosion, ferrous metals are used extensively because of their mechanical properties and low cost. Surface coatings such as paint are often used as a protective covering. Non-ferrous metals are not prone to rust, which makes them extremely useful in wet environments. Their main disadvantages are that they are usually higher in cost and generally have lower strength than ferrous metals.

9780170400336

Metal production

All common metals are derived from ores that are mined, processed and refined in a furnace to obtain metal of a workable quality.



Metal processing and production

Metals and their uses

Type	Name	Appearance	Properties	Uses
Ferrous	Mild steel	Smooth, grey	Fairly strong, hard and ductile	Most general applications
	High carbon steel	Grey	Hardest carbon steel	Cutting tools
	Tinplate	Shiny silver surface	Easy to form, less corrosive	Sheet and box construction

9780170400336

Type	Name	Appearance	Properties	Uses
Non-ferrous	Aluminium	Silver-grey, lightweight	Easy to work, non-corrosive	Casting, tub or sheet products
	Copper	Red-gold, shiny	Easy to work, solders well	Tube and sheet products, plumbing
Alloys	Brass	Golden yellow	Harder than copper, solders well	Bar, rod, cast and sheet products
	Duralumin	Light grey	Light, strong	Aircraft and vehicle parts, where strength is important
	Soft solder	Dull grey	Heavy, soft, low melting point	Joining sheet metal and electrical parts
Coated	Galvanised metal Zincalume	Zinc coating on steel or iron Zinc and aluminium coat Shiny, unevenly patterned surface	Coating protects from rust	Fencing, roofing, exterior nails, screws and bolts
	Powder-coated steel	Coloured surface (plastic powder melted to the surface)	Coating protects from rust, soft and shiny to touch	Household products
	Anodised aluminium or titanium	Very thin coloured surface (electrolytic process)	Decorative, increased corrosion resistance in aluminium alloys	Aircraft parts, household products

Health and safety issues related to metals

Most metals melt at a high temperature, and in liquid form can cause serious burns. However, metals for the most part are relatively safe in their solid forms, with dangers coming from sharp edges and incorrect lifting.

Machining operations create hazards associated with flying particles, heat and machine contact. Welding and forming operations create radiant heat, fume, vapour and fire hazards. Welding has the added possibility of eye damage and burning skin from a flash.

Refer to pages 39–43 for details of risk assessment and identifying and controlling risks related to materials and machinery.

Quality of materials

Steel in all its variations is by far the most widely used metal. However, there are many alloys and special-purpose products that have mechanical qualities far exceeding steels. A metal may need to resist corrosion for a marine application, be lightweight for a bike frame, or maintain its strength at high temperatures for an engine. The materials available that provide these properties are quite expensive, and are difficult to work because of their physical properties.

Environmental issues

The most pressing of environmental issues relate to the sourcing of metals. Sourcing may involve the destruction of forests and rivers if open-cut mining methods are used. Underground mining may also cause significant land degradation, through mine dumps and tailings dams. (For example, in Queenstown, Tasmania, the surrounding hills were stripped, and the rivers and surrounding environment were polluted through the mining of copper; the Ok Tedi gold

9780170400336

and copper mining site in Papua New Guinea resulted in the destruction and pollution of the surrounding areas.) Arsenic, other heavy metals and acids are sometimes used in the extraction of metals, and can leak into waterways and the water table.

smelting
the extraction of metal from its ore by heating and melting

Some environmental problems are also caused by the processing of metals. The **smelting** of some metals produces high levels of pollution (e.g. the smelting of sulfide ores contributes to acid rain, while the smelting of copper can release particles of copper and selenium into the air), and the production of other metals uses large amounts of electricity (e.g. the conversion of bauxite into aluminium).

On a more positive note, many types of metal can be successfully recycled, reducing the need for further amounts to be extracted.

Refer to page 125 for information on environmental strategies relating to metal products.

Getty Images/NurPhoto

Devastation caused when a tailings dam for an iron-ore mine collapsed, Bento Rodrigues, Brazil

Processes for metal

Metal preparation

Metal is manufactured in a number of forms; it is commonly available as:

- flat sheets
- stock with a variety of cross-sections, including square and round tubing, right angle and complex extrusions
- castings.

The amount of surface preparation required for your project will depend on the form you have chosen to use. Sheet metal and some stock, for instance, can be cut directly from the patterns you have drafted. But castings may require filing or machining to obtain a surface suitable for marking out. No matter what form the metal takes, an accurate **datum line** or reference edge should become the basis of all further marking out. Once marked, the pieces need to be cut accurately to minimise finishing time and wastage.

datum line
a fixed reference line to measure from

Measuring and marking tools

Most of the measuring and marking tools used when working with wood can also be used for metal. The main additional tools frequently used are:

- a scribe for scratching a marl onto a metal surface
- a centre punch for marking a point, creating an indent for drilling.

Cutting and sawing

There are many tools and techniques for cutting metal. Power shears, tinsnips, aviation snips and nibblers are all used with small- to medium-sized sheets. Large sheets and long, straight cuts can be made with a super shear or some other form of guillotine (but this may need to be done by a teacher). Thicker sections, such as flat bars and round stock, can be cut by a hand or powered hacksaw, metal band saw, cut-off disc or cold saw (Brobo saw).

Metal cutting tools and machines

A number of machines can be used to cut metal. Your choice will depend on the metal being cut, the type of cut required, tool availability, and your level of skill. They include:

- multi-tool
- power nibblers
- jigsaw
- power hacksaw
- oxyacetylene torch
- angle grinder (Extreme care and a full face shield is recommended when using an angle grinder) *
- rotary tube and pipe cutters (smaller and larger)
- guillotine *
- abrasive metal cut-off saw (can be wet) *
- cold or Brobo saw. *

* These machines are hazardous. They can only be used after training, competency testing, and under close supervision. The correct PPE must be worn. For some of these machines, it is recommended that students find alternative methods of shaping and cutting.

Plasma cutting

Plasma cutters use a high-temperature, high-pressure gas jet to pierce through the metal and blow molten material away. They are used for cutting sheet metals – steel, copper, brass and aluminium. Plasma cutters can be handheld tools or the larger industrial machines can be driven by computer (CNC).

Information about plasma cutting and tutorials for plasma cutting can be found online. Links are provided at http://nelsonpdtvce.nelsonnet.com.au.

A hand-cut decorative panel

This is a tool with a high level of risk. Make sure you are well trained in the plasma cutter's use and wear appropriate protective equipment. A full face shield is required, with eye shading that suits the current level used. Use similar protective clothing as worn for welding.

9780170400336

Drilling

Drilling is best accomplished using either a drill press or an electric hand drill. Solid metal should be firmly held in place by a vice, and sheet metal should be clamped to a backing board for support – this also prevents it rising up the drill spiral or gripping the drill and spinning.

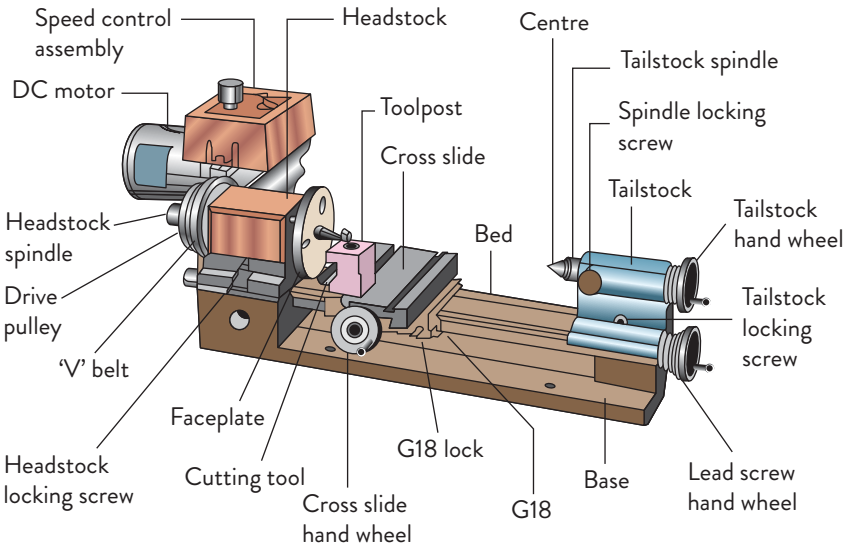
When drilling large-diameter holes in solid metal, the drill bit will need lubrication to prevent overheating. A fly cutter can also be used in the drill press for large-diameter holes in sheet metal.

Safety goggles are a must for all drilling operations.

Metal lathe techniques

The lathe is a versatile machine that cuts most types of metal. It cuts metal that is revolved against a cutting tool made of high-speed steel. The lathe is primarily used to make cylindrical and curved shapes, but is also useful for other shapes. It is capable of carrying out many operations, including parallel turning, taper turning, facing, knurling, drilling, boring and thread cutting. In industry these processes are fully automated and obtain accuracy of 0.001 millimetres and better.

Eye protection is a necessity for all lathe and spinning operations.



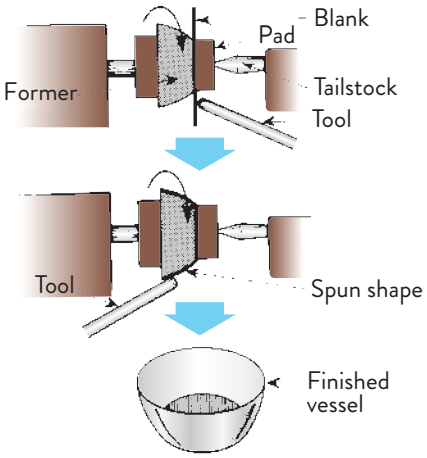
A metal lathe used for cutting

Shutterstock.com/ANATOL

Knurling grooves on the surface of a torch casing

Spinning

Sheet metal can be formed into a 3D shape by spinning: the sheet metal is pressed against a wooden or metal mould, using a burnishing tool. A woodworking lathe would be suitable for this process.



A wood or metal lathe used for spinning metal

Milling machine techniques

Milling removes material by moving/feeding it against a rotating multiple-toothed cutter. Milling can be used to produce accurate horizontal and vertical surfaces, as well as slots, keyways and profile cuts. Work is held in a vice or bolted to a machine table, which is moved parallel and at 90 degrees to the cutter axis. All operations can be CNC-controlled on computer-driven machinery.

Shutterstock.com/yuyangc

CNC-controlled metal milling machine at work

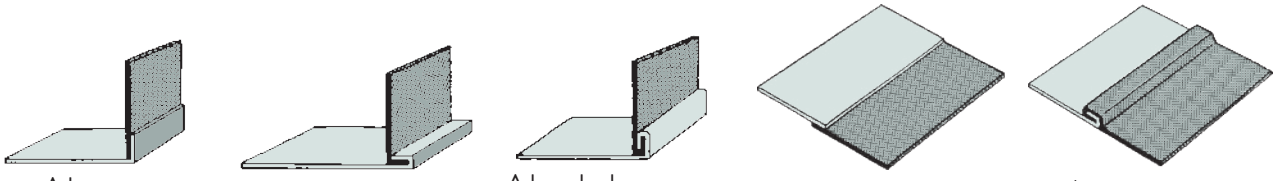
Grinding

When grinding, abrasive wheels are used to shape materials. The bench grinder is commonly used to sharpen tools and form curves, etc., in plate metal. It is often wrongly seen as an alternative to filing or other machine processes. Removing excess weld material and some shaping can be accomplished using an angle grinder.

Extreme care and a full face shield are recommended when using an angle grinder.

Bending

The techniques you choose to bend metal depend on the metal type, thickness and cross-sectional shape. Metal bars and rods are often formed using specially designed bending jigs. Thin and malleable bar material is often bent cold, while thicker sections usually need to be heated for accurate bending.



A lap seam (right angles) | A peined-down seam | A knocked-up seam | A lap seam (flat); this can be soldered and/or riveted | A groove seam

Bending and joining metal

9780170400336

Sheet metals can be bent to form folds, edges and seams, or beaten into hollow shapes with a mallet.

Accurate folding operations can only be done using folding bars, magnetic benders (Magna or panbrake benders) or a folding press. These create straight line folds and are suited to box construction, which has mainly straight edges. Industrial folding machines mechanise this process.

Shaped metal can also be extruded – flat sheet material is passed through a shaping form to change the profile of the metal (e.g. guttering, sheet edging).

Shutterstock.com/anantachat

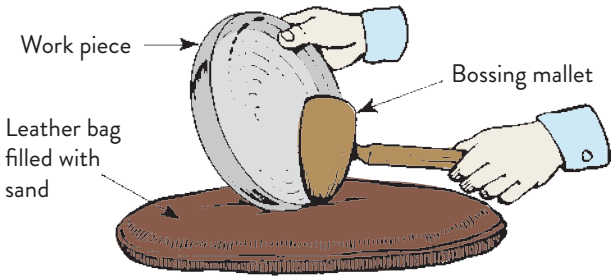
Manual pipe bender

Pipe bending needs to be completed with specific tools that cradle the pipe as it is bent, so that it isn't crushed, folded or twisted. Hydraulic pipe benders are used for bending large and thick-walled pipes.

Beating

Beating is probably the oldest method of metal forming. Today, it is most commonly used for decorative work and jewellery. This shaping process hardens the metal, and periodic **annealing** is needed to soften it and release accumulated stress in the grain structure.

annealing heating and slow cooling of metal so that it is more easily worked



Beating metal: the small end of the mallet is for hollowing and the large end is for smoothing out wrinkles

Heat treatment

Heat treatment is the process of modifying a metal's physical properties by controlled heating and cooling. Annealing is a type of heating process that involves heating the metal to above its recrystallisation temperature and allowing it to cool slowly. Some non-ferrous metals can be quenched (cooled quickly by being dipped in water) with little detrimental effect to the annealing.

Hardening can be carried out on ferrous metals with a high enough carbon content. The article is appropriately heated and quenched in either oil or water, depending on the reaction and grain structure desired.

Tempering is often carried out after hardening to toughen the article for practical use – this makes it less brittle. This involves heating to a specified temperature to remove some of the internal stress created during quenching. Oxide or temper colours appear on the metal's surface and are used to gauge the temperature.

Soldering

Soldering is commonly used to join sheet metals or fine jewellery. The process relies on a molten metal (solder) flowing between the components to be joined and adhering to the surface of both, forming a permanent join.

Two types of soldering are in common use:

- **Soft soldering** uses alloys of lead and tin, which melt at about 260 °C. The main applications for soft soldering are joining copper, brass, tinplate and galvanised iron.
- **Hard soldering**, commonly referred to as silver soldering, uses alloys of silver and copper in combination with other metals. It is used to create strong joins between steel, stainless steel, copper, bronze, high-speed steel and tungsten carbide articles. Melting temperatures can be altered for different purposes by changing the silver content.

It is possible to make solder joins in close proximity by using solders with different melting temperatures (the solder with the highest melting temperature is used first).

Flux needs to be applied to metal surfaces before soldering to minimise surface scale during heating, as scale stops the solder flowing evenly on the surfaces to be joined. The heat to melt the solder is supplied by a soldering iron or gas torch.

flux
a chemical that stops the oxidisation of heated metal and allows solder to attach to the metal

There are a variety of soldering tools available - you need to choose the one appropriate to the scale of your join, the solder and the materials being joined. There are some very useful tutorial videos that can show you how both types of soldering are done.

Joining metal with bolts, screws and rivets

Joining processes and techniques are the basis of all fabrication. When choosing a technique, you must consider the uses of the object. Semi-permanent fasteners – such as screws and bolts – are widely used because of their mechanical strength and their ease of use, particularly in applications that require disassembly.

Shutterstock.com/george photo cm

Self-tapping screws create their own thread

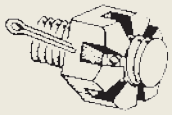
There are two classes of threaded fasteners:

- **Screws** have an internal driving slot or shape in the head – e.g. a slotted, square, Phillips or Allen key head – and a tapered threaded section (and often a non-tapered unthreaded shank), and form their own receiving thread in the material being fastened.
- **Bolts** have a solid head so that the bolt can be turned by the use of an appropriate tool (e.g. moved by a spanner), and are attached into a threaded hole or nut. Bolt heads can be different shapes, but are often hexagonal. The threaded section of a bolt is usually cylindrical, rather than tapered.

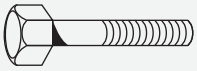
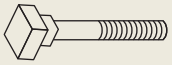
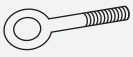
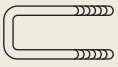
Both screws and bolts come in a range of sizes that are designated by their length, diameter and thread type or pitch.

Types of nut

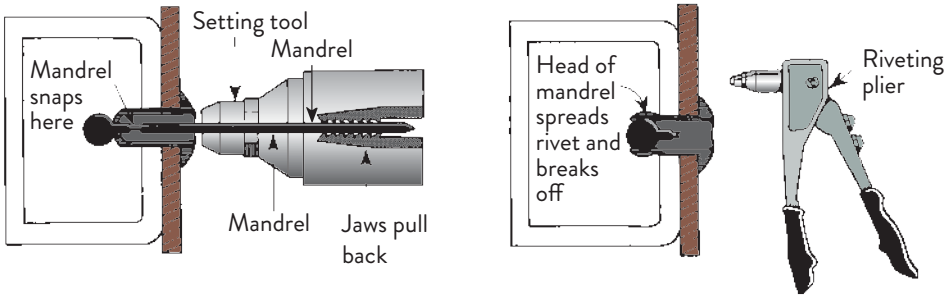
Type	Uses	
Wing nut	For quick removal	
Square nut	For timber	

Type	Uses	
Nylon nut	Self-locking	
Hexagonal nut	For steel	
Lock nut	To prevent movement	
Castle nut and split pin	Locks in place and can be adjusted	

Types of bolt

Type	Uses	
Hexagonal head	General fastening	
Square head	Securing shafts and rods, or clamping to pipes	
Eye bolt	Fastening point for hooks, lines or wires	
Square U-bolt	Securing square and rectangular sections	

Pop riveting is another semi-permanent joining technique that has good mechanical strength. It is used mainly with sheet metal and can be easily removed by drilling out the rivets.



Pop or blind riveting

9780170400336

Threading

There are many threading processes, including cutting threads with a tap or die, thread milling, single-point thread cutting, thread rolling and forming, and thread grinding:

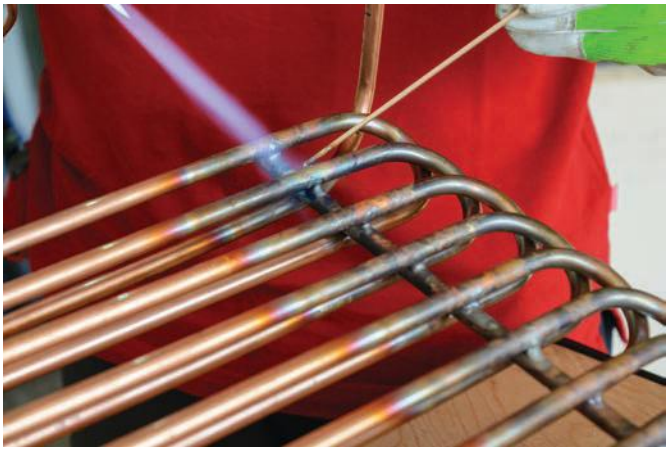
- A tap is used to cut a thread on the inside surface of a predrilled hole.
- A die is used to cut a thread on a preformed cylindrical rod.

Shutterstock.com/Miriam Doerr Martin Frommherz

Tap and die set

Brazing

Brazing involves joining metal together with a filler metal that has a lower melting temperature. The parent metals (the parts to be joined) are not melted, but are heated to a temperature high enough to melt the filler metal, which flows into the join. Flux is needed to ensure that the filler attaches to the parent metal – some brazing rods can be bought pre-coated in brazing powder.



Shutterstock.com/Bildagentur Zoonar GmbH

Brazing with a gas torch

Welding

Welding is different from soldering and brazing. It is done at a higher temperature – the parent metal is melted to form part of the join, and a filler rod is used to add material to the weld and complete the join. All forms of welding affect the grain structure of the surrounding metal and change its mechanical properties. Care should be taken to carry out appropriate heat treatment on items subject to any form of fatigue loading.

Gas welding

When gas or oxygen/acetylene welding, heat is supplied by burning a carefully adjusted mixture of oxygen and acetylene, giving a flame temperature of about 3000°C. The metal to be joined is melted by the gas torch to form a small pool of molten metal that fuses on cooling to join both pieces. The filler rod is added to the weld pool as it progresses along the join to create a flat surface and compensate for parent metal used to bridge the join. Spot welders can also be used for small tacking jobs, and are quicker and require less skill to operate.

Safety procedures must be rigorously followed for all welding. Protective eyewear and clothing are essential.

9780170400336

Shutterstock.com/SasinTipchai

Electric arc welding – note that personal protective equipment (PPE) is worn

Electric arc welding

Electric arc welding is probably the most widely used form of joining in metal fabrication today. The heat for electric arc welding is supplied by a controlled arc between the filler rod and the metal to be joined. The diameter of the electrode rod and the current supplied to the arc need to be adjusted for varying thicknesses of metal. The electrode performs the same function as a filler rod in gas welding by eroding and adding its metal to the weld.

Special-purpose welding processes

In recent years, a number of special-purpose welding processes have been developed to cater for the increased use of aluminium, stainless steel and exotic metals. **TIG** and **MIG welding** processes both use gas shields around the weld area to prevent oxidation and improve the weld quality.

TIG welding
welding using a tungsten electrode; used for welding stainless steel, aluminium, etc.

MIG welding
welding using a wire electrode and shielding gas; used for welding most steels and some other metals

Getty Images/Vince Bucci

A wax form ready to be moulded

Casting

Metal casting is the process of pouring molten metal into a mould cavity, which has been formed around a pattern of the desired shape. When solid, the casting can be removed from the mould, and machined or finished as required. Although hazardous, care and planning can allow you to create unique items for your design project. Aluminium is probably the best choice of metal for most school situations because of its low melting temperature and ease of casting. In 'lost wax' casting, the form to be cast is shaped in wax, placed in the mould material, the mould is heated and the wax flows out, leaving a hollow for the metal to be poured into.

Casting is also used at an industrial level to form mechanical parts and components.

3D printing in metal

Currently, 3D printing in metal is very expensive, but there is great potential for creating metal forms that are intricate and difficult to shape using other technologies. Being an additive construction method, 3D printing can reduce construction time and waste. (Other methods cut and shape parts from larger pieces, creating much waste material.)

9780170400336

Industrial tools/processes

- CNC milling and laser cutting machines – these are used to cut very accurately, and consistently repeat jobs.
- Industrial band saws can be used to cut metal with a slow band speed, and slow feed rates.
- High-pressure water abrasive cutter (can be CNC) – uses water with abrasive material.
- CNC plasma cutters.
- Stamping – cuts shapes with a die, can also press into a mould (e.g. car panels) – used in industry for repeatedly cutting and/or pressing the same shape.
- Robotic welding – accurate joining, particularly for seams that need consistent quality or in hard-to-access positions.

Decorative treatments

The surfaces of most metal objects can be left with a high polish, but sometimes more decoration is needed to add to the object's appearance.

Pierced designs

A piercing or scroll saw can be used to cut shapes in thin sheet metal, creating decorative patterns and shapes. A fine saw blade is needed to be able to cut tight curves, and delicate shapes and lines.

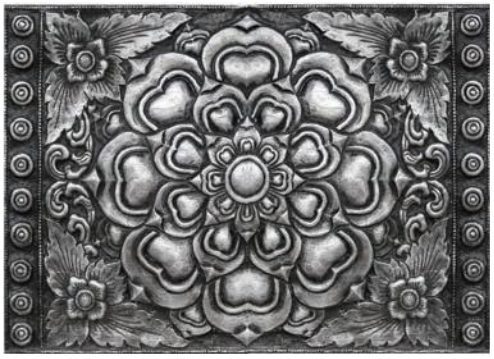
Larger decorative designs can be cut into thicker sheet metal with a plasma cutter.

Getty Images/DEA/G. Cigolini

An example of decorative metal piercing

Surface shaping

Chasing and **repoussé** tools can be used to punch patterns into the surface or create relief designs. Hammer marking is also an option: small round facets are created by striking the surface with a ballpein hammer.



Shutterstock.com/Sivadonv

Repoussé

chasing
grooves or indentations in a surface

repoussé
design raised by hammering on the reverse side

Enamelling

Enamelling involves melting finely powdered glass onto a metal surface to create a pattern. Plain colours can be enamelled or a range of coloured powders can be applied to a surface and as they melt, they flow or can be manipulated to make patterns. Traditionally, metal wire has been used to separate different coloured sections in very fine enamelled work called 'cloisonné'.

Surface marking

Engraving and etching techniques can be used to create complicated and detailed patterns.

Engraving involves scratching or cutting the surface – it can be carried out by hand using a Dremel-type tool, or can be done using a milling machine.

Shutterstock.com/Aslan Ivanov

Simple enamel/cloisonné work

9780170400336

Acid is used to bite into the surface of metal to create an etched design. An acid-resistant medium is applied to all areas not to be etched, and then the metal is submerged in an acid bath until the required depth of etching is achieved.

Extreme care is needed when using acid, and etching work should be carried out in a fume cupboard.

Surface finishing and colouring

A clean, smooth surface is essential for any finish to be applied successfully.

Files or grinding wheels are used to remove any large amounts of excess metal and surface imperfections. The surface can then be smoothed using emery cloth of progressively finer grades; final polishing may even be done on a buffing wheel.

Depending on the type of metal, a surface finish may or may not be required:

- Non-ferrous metals (such as brass, copper and aluminium) are often just polished, as they are not unduly affected by moisture and form their own protective oxide layer.
- Ferrous metals, on the other hand, need to be protected from corrosion. This is often accomplished by painting.
- Cor-ten or weathering steel develops a stable protective rust layer on its surface, which doesn't require further finishing.

Most surface coatings, such as paint, are easy to apply and give good service when the metal is properly prepared and primed.

Enamel paints provide an opaque finish in a wide choice of colours, while lacquers are often sprayed over polished brass or copper surfaces to allow the natural colour of the metal to show through, yet prevent oxidation and dulling. Other paint options include metallic and hammer-tone finishes, which create special effects.

Metal colouring can also be achieved by exposure to chemicals that enhance appearance and, in some cases, form protective coatings:

- Potassium sulfide dissolved in water will change the colour of copper and brass from bronze through to black – the colour intensity depends on the solution strength and immersion time.
- Sodium thiosulfate solution heated to about 50°C will produce red, rose, purple, green, blue and grey.

Anodising and nickel plating are electrochemical processes that form a protective film on the outside of an article. Other effective methods of surface finishing are plastic dip powder coating and galvanising, both of which provide a thin coat of non-corrosive material over the article's surface.

Anodising titanium produces a wide range of colours that are often used in jewellery

PLASTICS

Origins and properties

polymer
a material with a long-chain molecular structure

Plastic is a term used to describe the long-chain organic **polymers** that can be formed by extrusion, moulding, spinning or casting processes. The development of plastics began in about 1860, when a manufacturer of snooker and billiard balls offered a $10 000 prize to anyone who developed a satisfactory substitute for natural ivory. John Wesley Hyatt developed a method of pressure-shaping pyroxylin, a cellulose nitrate, with camphor as a plasticiser and

an alcohol solvent to form celluloid. Although highly flammable and light-sensitive, celluloid remained in popular use for shirt collars, dental plates and other products until 1920. Table-tennis balls are probably the only celluloid products readily available today.

Plastics are used for a huge range of products every day. In fact, many types of plastics are replacing traditional materials (e.g. alternatives for timber and metal in seating, for ceramic in crockery, for glass in spectacles, etc.). Plastics such as polyurethane are commonly used as a finish for timber.

General properties of plastics

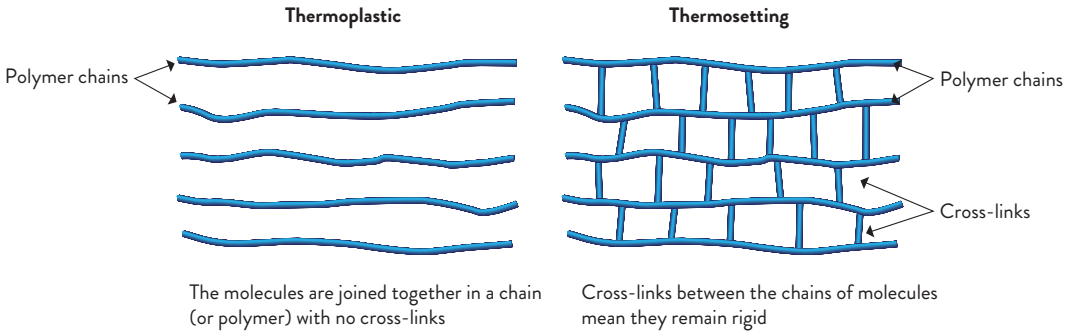
Plastics generally show high strength-to-weight ratios, are excellent thermal and electrical insulators, and have a good resistance to attack from acids, alkalis and solvents. They have few directional properties – unlike timber, where grain orientation is critical to strength – and withstand all types of stress. However, the strength of plastics is generally lower than that of metals.

Even though there is an almost indefinite range of plastics available, all may be classified as either **thermoplastic** or **thermosetting** polymers:

- When thermoplastic polymers are heated, they become flexible and can be easily shaped and reshaped. If you look at the diagram below, you can see that there are no cross-links in thermoplastics and that the chains of molecules can slide over each other.
- Thermosetting polymers do not soften when heated because the chains of molecules are cross-linked together and remain rigid. They cannot be reshaped once set.

thermoplastic
plastic that becomes flexible and can be shaped when heated; can be re-formed many times

thermosetting
a plastic that cures (sets), usually through heat or chemical reaction, and then cannot be re-formed



The molecular difference between thermoplastic and thermosetting polymers

Plastic sources

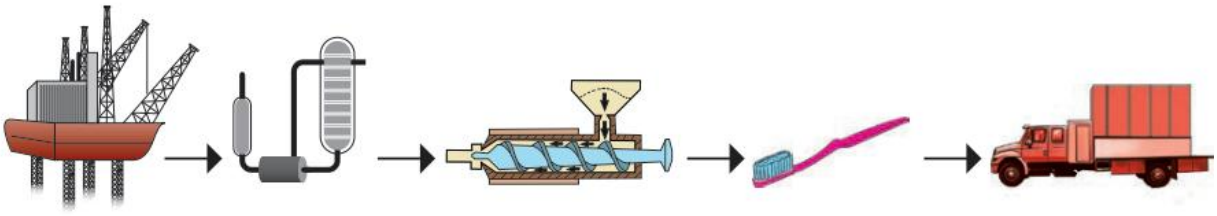
The majority of plastics were originally made of resins derived from vegetable matter. Today, however, most plastics are based on petrochemicals.

Condensation and addition polymerisation are the two methods used to produce the polymers that form the bases of all plastics:

- Condensation reactions occur when two or more dissimilar compounds react to produce a polymer and by-products, such as water, ammonia or glycol. Typical examples of this process are nylon, polyurethane and polyester.
- Addition reactions occur when **monomers** of a similar structure link together – without changing their chemical composition, they create chains of specified lengths and generate no by-products. Polyethylene, polypropylene and polyvinyl chlorides (PVC) are all produced by this method.

monomer
a small particle that bonds with others to create a polymer

9780170400336



The plastics production process

Plastics production

The manufacture of plastic and plastic products involves synthesising or creating the basic polymer from raw materials, compounding it into a useful material and then shaping it to its final form.

Health and safety issues relating to plastics

Plastics can be among the most volatile materials. They require extreme care and should be treated as any other type of synthetic chemical. For example:

- Although sheet materials are relatively inert, cutting and sanding operations produce dust hazards, and hot-wire cutting should not be carried out in schools because of the toxic fumes it produces.
- When they are combined, two-part plastics (resins that use a chemical catalyst) often produce fumes that can cause nausea, while skin contact can cause dermatitis. They should be used in a fume cupboard wherever possible.
- Some solvent glues that react with the surface of acrylics are banned from use in schools because of the dangerous fumes produced and dangers of direct skin contact.
- Fire hazards can arise from incorrect storage and from mixing incorrect ratios of catalyst to resins.

Refer to pages 39–43 for details of risk assessment and identifying and controlling risks related to materials and machinery.

Refer to page 125 for information on environmental strategies relating to plastics products.

Quality of materials

There are a large number of plastics, all with differing characteristics and properties. Plastics need to be carefully selected if they are to perform well in their chosen situation. An inappropriately chosen plastic will reduce the quality of the end product. Plastic that is contaminated with impurities (possibly through poor recycling processes) will have reduced quality, and may only be appropriate for low-grade products.

The quality of plastics can be improved through the addition of specific chemicals during processing, e.g. chemicals can provide resistance to weakening through exposure to UV light.

Fibre-reinforced plastics (e.g. fibreglass) are often used for special-purpose products, such as boats, or carbon fibre for bicycle frames. Remember that consideration of the fibre fillers as well as the resins is needed to ensure quality.

The creation and processing of plastic materials and components is highly mechanised and standardised; thus quality is uniform and consistent when compared with natural materials, such as timber, that have considerable variation in their structure.

9780170400336

Plastics and their uses

Type	Name	Appearance	Properties	Uses
Thermoplastic	Acrylic (Perspex)	Hard, smooth, lightweight	• Brittle, easily scratched	• General purpose
	Polystyrene	Soft, flexible	• Easily shaped	• Vacuum forming
	Expanded polystyrene	Light, soft 'pressed balls'	• Good insulation • Absorbs shock • Burns with poisonous gas	• Packaging • Heat and sound insulation
	Rigid PVC	Stiff, hard	• Weather-resistant • Tough at room temperatures	• Plumbing • Outdoor furniture • Roofing
Thermosetting	Polystyrene resin	Clear viscous liquid	• Tough • Brittle when cast • High strength when used with glass matting	• Encapsulating • Casting • Surfboards, boats, etc.
	Phenolic resins	Viscous liquid	• Water-resistant • Good bonding • Easy to use • Sets with heat	• Surface coatings • Filters • Brake linings
	Epoxy resins	White and clear two-part viscous liquids	• Good bonding • Waterproof • Tough when used with glass matting	• Two-part glues • Boatbuilding

Environmental issues

The sourcing of most plastics involves the use of non-renewable resources, such as petrochemicals. The processing of these materials causes environmental damage through the production of pollutants. In addition, some plastics emit hazardous fumes during their useful life (off-gassing), and the common use of plastics in the home and work/school environment increases our exposure to those fumes.

The disposable nature of many plastic products increases waste problems, particularly as many commonly used plastics do not decompose but last for hundreds of years. These problems include the increased need for landfill and the damage caused to sea life by plastic rubbish getting into waterways. Huge rafts of mostly plastic rubbish are collected by sea currents (e.g. the Great Pacific Garbage Patch), and litter the sea floor. A growing problem with plastic is that with wear and tear, it breaks into smaller pieces (nanoplastics or microplastics), which are ingested by birds, animals and fish (this is particularly a problem with 'degradable' plastics and with the washing of synthetic clothing).

Shutterstock.com/Mohamed Abdulraheem

The spread of plastic rubbish near landfill

9780170400336

As with metals, a positive environmental aspect of many plastics is that they can be recycled, but for this to be successful, effective economical recycling systems need to be more fully implemented and consumers need to improve their level of recycling. Because plastics last a long time, they should be used for long-lived products rather than disposable products, but plastics can reduce the need for timber in many products, reducing the removal of forests. Products need to be thoughtfully designed so that they can be easily dismantled and the thermoplastic content can be retrieved, sorted and reused. It is important that plastics are labelled for effective recycling, as contaminants reduce the quality of recycled plastics. Most kerbside recycling collections handle plastics labelled with numbers 1 to 6.

To revise environmental impacts, go to pages 121–4.

PETE	HDPE	PVC	LDPE	PP	PS	OTHER
Polyethylene terephthalate Soft drink bottles, mineral water, fruit juice containers, cooking oil	High-density polyethylene Containers for milk, cleaning agents, laundry detergents, bleaching agents, shampoo, washing and shower soaps	Polyvinyl chloride Trays for fruit, plastic packing, bubble foil and some cling film foils to wrap foodstuffs	Low-density polyethylene Shopping bags, highly resistant bags and some cling film wrappings	Polypropylene Furniture, luggage, toys, cars: bumper bars, lining	Polystyrene Toys, hard packing, food trays, makeup bags, costume jewellery, CD cases	Other plastics, including acrylic, polycarbonate, polyactic fibres, nylon, fibreglass

Symbols for different types of plastics

Processes for plastics

Preparation

The making of plastic articles does not require surface preparation. Marking out is usually the first step – even in fabrication, where the components are cut from sheet material. Many sheet materials have a protective paper or plastic coating, useful for marking out.

Cutting

Acrylic and most other rigid plastics are easily cut with hand saws or power saws. Straight-line breaks in acrylic may be made using the 'score and snap' method, which involves scoring a break line and levering the excess plastic until it breaks.

Soft and flexible plastics, such as polypropylene, can be cut with shears, and on some occasions with scissors or a craft knife.

Shaping

Plastics are a group of materials that in general are easily shaped and formed. Many of the tools and processes used to shape wood and metal may be successfully used with plastics, e.g. filing, sanding, drilling and sawing are all acceptable methods of shaping plastic articles.

9780170400336

However, the difference in working properties between plastics and other materials must be taken into account when filing or sawing. For example, as many plastics are brittle, finer blades are required for cutting, and a shallower drill profile is required when drilling.

Shaping processes for thermosetting plastics and thermoplastics need to be carried out at different stages in their production:

- Thermosetting plastics are shaped after mixing with a **catalyst**, usually through moulding prior to **curing**.
- Thermoplastics may be shaped at almost any convenient time; they are simply heated until soft, and formed to the desired shape. Many thermoplastics exhibit shape memory and return to their original or sheet form when reheated.

catalyst
a chemical, or heat, that causes a reaction or molecular change

curing
the stage when a thermosetting plastic has set and the reaction is complete

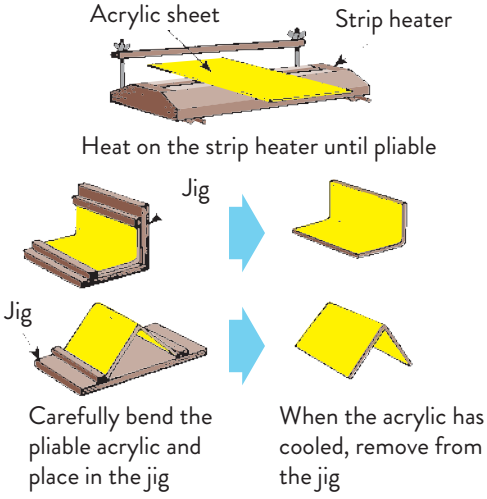
Bending

Bending of thermoplastics is easily achieved using a strip heater, oven or other heat source. To create straight-line bends, the plastic is placed across the heater element until it is flexible and then formed to the appropriate angle before cooling.

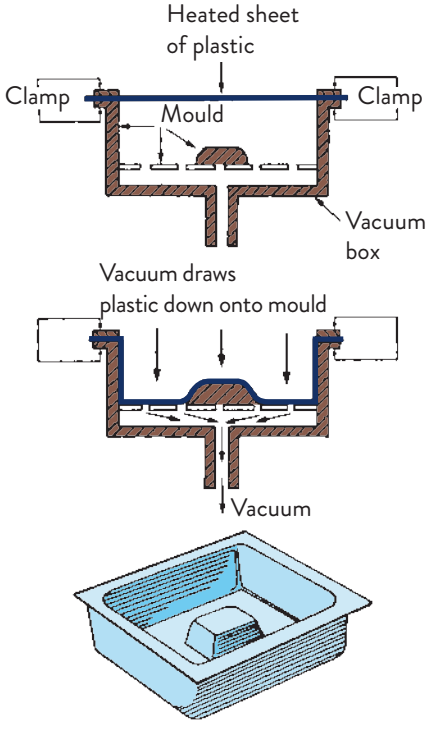
Industrial processes for manufacturing

Vacuum thermoforming

Vacuum thermoforming involves heating the plastic and drawing it down over a mould by vacuum pressure while it is still in a flexible state. Very complex shapes can be easily and accurately formed using this process.



Straight-line bending of a thermoplastic



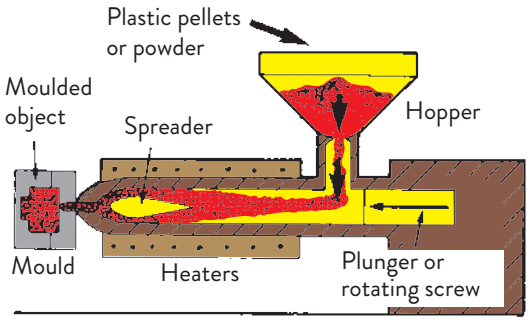
Vacuum thermoforming

Injection moulding

Injection moulding is an industrial process that involves plastic material in a powder or granule/pellet form being fed into a hopper or bin, which in turn feeds a barrel-shaped heating chamber. The molten plastic is forced into a mould cavity of the desired shape by a plunger, which moves forward at fixed intervals.

When cool, the mould is opened and the newly formed article ejected.

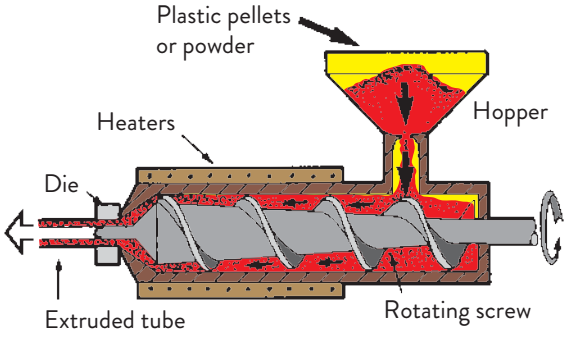
The mould then closes and the cycle repeats. This process is really only suitable for mass production because the tooling costs are high.



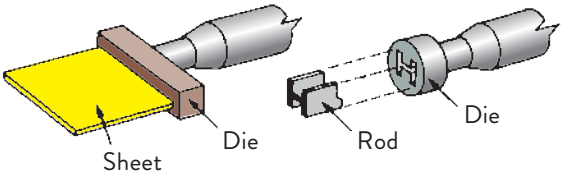
Injection moulding

Extrusion

Extrusion involves plastic material in a powder or granule/pellet form being fed into a hopper or bin and down to a revolving screw inside a heating chamber with a die at one end. The plastic is forced out through the die by the screw action and comes out as a pipe, tube, rod or sheet, depending on the shape of the die.



An extrusion press



Extruded sections from an extrusion press

Compression moulding

Compression moulding is used mainly with thermosetting plastics. A weighed amount of plastic powder is placed under heat and pressure in a mould cavity. The plastic melts and then undergoes a chemical change, which sets its form.

Calendering

Calendering is a process that squeezes melted plastic between rollers to form a continuous film. It is faster and cheaper than extrusion. This process is used to make cling film and food packaging.

Foaming

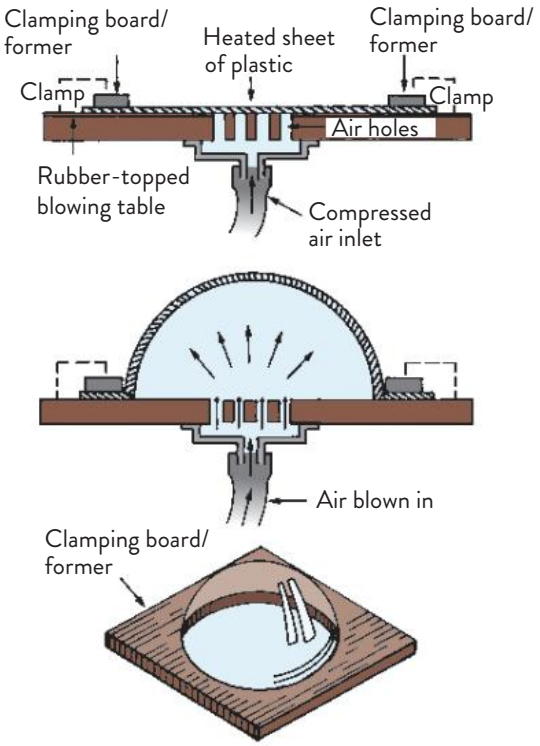
Foaming involves the use of rigid polyurethane material, which has low heat conductivity and is fairly water-resistant. It can be mixed and expanded inside moulds to form specific shapes – e.g. to fill plastic sailboards. A foaming catalyst is added to the liquid plastic

component – they are mixed at room temperature and allowed to complete their reaction. The temperature is important, as it determines cell size, density and cream time of the foam.

Blow moulding

With free blow moulding, air pressure is used to create domes and other even, circular shapes from acrylic. The sheet plastic is heated and clamped to a circular, square or rectangular base plate. Air is then used to inflate the plastic dome. Skylight covers are manufactured using this method.

Another form of blow moulding, to create plastic bottles and containers, involves using an extruder to form a hollow plastic tube, which is inflated against the sides of a mould and cooled to form the bottle/container.



Free blow moulding

Fibre and resins

Thermosetting plastics can be used to laminate/mould glass cloth or to mat foam blanks, or to build up layers within prepared moulds.

In both cases, the polyester resin is used to bind glass fibres in a tough and flexible matrix. The cloth is laid in position and the resin is worked through the glass with a squeegee or roller. Subsequent layers can be built up or filler coats applied to create a smooth surface.

Vacuum bagging is mainly used with epoxy resins. The forms or parts to be epoxy-coated or soaked are placed in a disposable covering, which is in turn placed inside a larger airtight bag. This is often done in a mould to form the component into a set shape. Air is then removed from the airtight bag to create an evenly exerted pressure on all parts of the object at the same time. When cured, the object is removed and sanded smooth for finishing. This method is used with carbon fibre to ensure the penetration of the epoxy into the fibre mat.

Casting

Thermosetting resins can be cast to embed articles or form solid shapes. The mixed resin is simply poured into the desired mould and allowed to set. Heat build-up can be a problem if too much catalyst is used.

Machining

Most solid plastic forms can be shaped using metalworking machines and processes. The lathe and the milling machine are two of the most useful. Cutting speeds must be reduced to prevent heat build-up.

Joining plastics

Acrylic and other plastics are easily joined to wood or metal by means of screws, nuts and bolts, and other mechanical fasteners. Contact glues are also effective.

Plastic-to-plastic joins can be achieved by gluing with suitable cements.

9780170400336

Use of ethylene dichloride

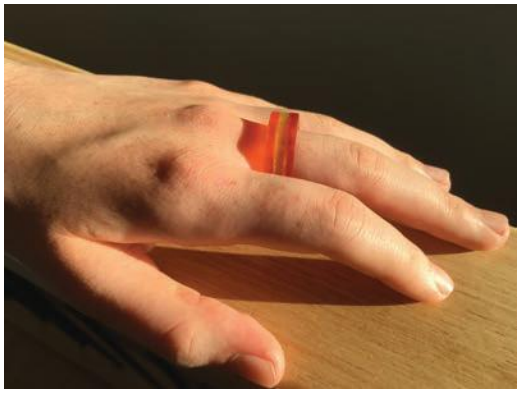
In industry, plastics such as acrylic can be joined together with ethylene dichloride (dichlorethane), which needs light pressure to be applied to the article being glued. However, because of the hazardous nature of this chemical, its use in schools is prohibited. As an alternative, there are solvent cements that can be used to join such plastics. Note that these still have hazardous vapours and need to be used with care.

Varied welding techniques can also be used to join plastics. Solid material can be welded using processes similar to those for metal. The heat source is usually a hot air gun, or it can be a closely controlled flame. Spin welding is a technique that uses friction-generated heat to melt the plastic and form a join. A hot tool or roller can be used to seal plastic film.

Decorative processes

Laminating

Layers of different coloured plastic, such as acrylic sheet, can be glued together to form a more solid block. Coloured powders can be sandwiched in the layers for decorative effect. The glued material can then be shaped and finished.



A laminated acrylic ring

Laser cutting and engraving

Plastics, particularly acrylic, can be effectively engraved and etched using a laser cutter or CNC milling machine. Very fine, delicate fretwork can be created, or a detailed photo or illustration can be produced. Lighting can highlight a design on transparent acrylic to great effect.

Finishing plastics

Most plastics require very little surface finishing because of their manufacturing processes. Fabricated and moulded articles usually only require minimal polishing except for the edges that have been cut to shape or joined. These often need smoothing. Filing, sanding or scraping techniques can be used until the rough edge is smooth enough for polishing. Acrylic can also be flame treated to remove imperfections on cut edges; extreme care should be taken when using this method.

Polishing can be done by hand or machine. A wool buff and fine abrasive liquid or car polish are usually recommended to create a high-gloss surface on plastics.

Jewellery by Heart & Noble, using laser-cut plastic

Getty Images/Stephen Lovekin

9780170400336

CASE STUDIES FOR RESISTANT MATERIALS

CASE STUDY

Bryan Cush, Sawdust Bureau

Set up in an old workshed at Jack's Magazine next to the Maribyrnong River, Sawdust Bureau creates beautiful handcrafted furniture from Australian timber. Although the setting is historic, Bryan combines an appreciation of fine craftsmanship with the use of 21st-century design tools and design thinking.

Sawdust Bureau

Bryan has a background in architecture, and completed a module of furniture during his masters at Melbourne Uni. After working for some time, he felt a bit 'duped' about architecture as a career – it wasn't as creative as he'd expected, and the focus was mainly on management. He was also dispirited by the process of developing multi-residential buildings that are 'designed by spreadsheet' and built for economic benefit, without considering quality or the residents' needs. Bryan re-evaluated, and concluded that the area in his training that gave him most satisfaction was furniture making. He found the cheapest workshop space available, bought a few tools and started tinkering on weekends. He was given a few small jobs, started diverting his salary to buy tools, and then the jobs got bigger, involving more time. Bryan ended up working 45 hours a week in architecture and 30 hours in the workshop. He gradually reduced his architecture working hours until he was able to quit and work full-time in the workshop with the help of a business grant. Bryan was able to set up a basic workshop without industrial-level machinery, but with enough to do the type of construction work needed for his designs.

WHY WOOD?

Bryan likes that wood has character, that no two pieces are the same. This is challenging, but also satisfying and enjoyable. He handpicks all of the timber, looking for pieces with veins and features to add interest to his work. Although he works with steel, Bryan finds it a static material; wood requires more thought and 'art'. He finds some Australian timbers tricky (e.g. ironbark) – 'beautiful, but brutal'.

SUSTAINABILITY

Bryan prefers to be quietly sustainable by implementing good practices.

- He only uses Australian timber – it's such a simple way to reduce the carbon footprint of his work by making sure timber hasn't travelled vast distances. Even after championing Australian timber species, Bryan lost some projects because he refused to work with overseas timbers.
- He buys just what he needs for each job, using computer tools to develop cut lists that are accurate and reduce waste. All of the timber he buys is FSC certified from reputable yards.
- Bryan uses the minimal material structurally needed, and works with standard sizes. The *Pinch* table uses 40 × 19 mm Victorian ash, glued flat and side on, giving it greater structural strength with less material.
- Approximately 30 per cent of the timber Bryan uses is recycled, bought de-nailed to reduce processing time. The recycled material is often better – more stable and with greater character. He always tries to leave some element of the recycled piece showing through, rather than stripping it all the way back. This keeps a connection with its past, especially if a client brings in timber with some attachment (e.g. from a demolished house).

9780170400336

FORMS OF WORK

Bryan works on a mix of projects:

- one-off bespoke pieces – very expensive in terms of time (currently the core of his work)
- his range of designed products.

Currently, he is developing a prototype for a furniture retailer, simplifying the *Pinch* table for less time-intensive production.

Bryan works to order and keeps very low stock levels - a necessity due to limited storage space. However, if he gets an order for a *Pinch* table, he'll probably make two, as the second will be 45 per cent cheaper due to time efficiencies. Bryan likes variety, and happily adapts his own designs or develops something new to suit the needs of the client. He refuses to copy the designs of other people, and is careful to protect the intellectual property rights of others, which he feels aren't protected well by Australian IP law. He limits production numbers to 49 of any design, and each one is numbered. This means that they are seen as artwork in terms of copyright law (if more than 50 are produced, a product is seen as mass-produced). If someone wants a new design made, Bryan will negotiate a cheaper price if he can use the design in his range. If the client wants exclusive ownership of the idea, they have to pay for his creative time.

Sawdust Bureau

Ostberg bench

PROCESS

When working for a client, Bryan develops a brief but this is usually verbal. It's important for the client to come into the workshop to understand the way he works, and to see timber samples, inlays, joints, etc. Bryan also creates shared folders where the client can drop images of the types of objects they like. He'll sketch, develop CAD designs and 3D modelling of the object or, if it is a fit-out, of the whole space. To help the client get a 3D grasp of designs, Bryan produces 3D printed models of different options (outsourced at high quality). After discussions with the client, designs will be tweaked and a final design decided on. Bryan uses an obscure CAD software program that is good for product design – he knows it well and it gives him the specific information he needs. His architecture background has given him the knowledge and speed to model and render quickly in CAD. Bryan then uses the cut list produced from the CAD program to purchase timber, selecting the timber quality and features the client wants. He feels that this attention to detail and the ability to make each piece unique separates his work from mass-produced furniture.

Sawdust Bureau has a couple of interns who work with Bryan on production – a furniture maker trained in Germany and another with a product design background from RMIT. These women also work on their own projects. Bryan appreciates that not only can they make well, they can also critique products on how they look and function, and give him feedback. He wants to keep the business fairly small so he can keep control over the details, and to stay 'hands-on' (rather than moving more into managing, marketing and sales).

All finishing is done in-house, mainly with Danish oil. Bryan sees his products as 'lifetime pieces', and oiled finishes allow for easy repair and rejuvenation (hard varnishes are much more difficult to repair when damaged). For dining tables and objects that need a more durable finish, Bryan uses Osmo oil finishes ('eco-friendly', natural). Finishing stages are sometimes done outside, but for big pieces, the workshop has to be vacuumed to manage the dust. All finishes are hand applied, not sprayed, and some of the angular parts of the products are pretty difficult to reach. It's time-consuming, as most sanding is done with portable sanders and by hand, but Bryan loves this stage, when the features of the timber are revealed.

QUALITY CONTROL AND OH&S

Bryan spends time going through processes and tricky stages with the other staff, and sees the importance of learning through mistakes. He also sees that it is his responsibility to ensure that staff are competent with machinery (OH&S). The dust situation is much improved in the new studio thanks to good ventilation and a dust filter (very effective for extracting fine particles) – in the old studio, dust masks were worn all day. Bryan is very conscious about safety; if something

9780170400336

feels dangerous or wrong, he will stop and find alternative ways of machining. The worst incident he has had was while unloading timber, when a very large splinter went into his hand and hit bone. Bryan uses lots of small methods – sleds for cutting, etc. – to make everyday things safer. He keeps improving his skills through reading, watching videos (though he's wary of some of the dodgy practices shown), doing practical courses, 'real world stuff'.

Sawdust Bureau

Ply Parasite side tables

Sawdust Bureau

The *Meowhaus*

MARKETING

About 20–25 per cent of Bryan's time is spent working on the website, Instagram, YouTube, Pinterest, photography, branding, etc. He feels it's essential for designers to be multifaceted and work on all sides of their business. Instagram works well for building a profile, and to connect with clients, tool suppliers (sponsorship), and with the really supportive and sharing furniture-making community. After a flood in the old workshop, many offers of help came from furniture makers Bryan had never met.

INDIGENOUS CONNECTIONS

Through Instagram contact, Bryan started collaborating with Darwin-based Gurindji artist Sarrita King, who works in a dot painting style. She sent him an image of her work on canvas – an interpretation of the Southern Cross with path lines and family lines – which he translated onto a timber table inlaid with brass. The *Ancestors* artworks were displayed together at the 2016 Melbourne Design awards and were awarded a gold medal. (View a time lapse of brass inlaying on the Sawdust Bureau website.) Bryan continues to work with Sarrita and her sister, Tarrise, on other pieces. He has also explored other art collaborations and decorative techniques – e.g. transferring prints onto timber with a gel medium.

Sawdust Bureau

Bryan and Sarrita with their *Ancestors* pieces

9780170400336

For more information about Sawdust Bureau, go to their website. A link has been provided at http://nelsonpdtvce.nelsonnet.com.au.

Bryan Cush was interviewed by Jill Livett at Sawdust Bureau in 2017.

CASE STUDY

Jacki Staude: metalworker

BACKGROUND

Jacki Staude studied Fine Arts and majored in sculpture at Ballarat University. She works primarily in metal and creates fences, sculptures, gates and other structures.

All her work consists of commissioned, one-off pieces. Clients come to her after seeing examples of her work or hearing about her through word of mouth. At the initial contact, Jacki will visit the site and the client will explain their requirements. Often the client doesn't know exactly what they want, so she will show them photos of her previous work, make suggestions and gauge their response to certain aspects.

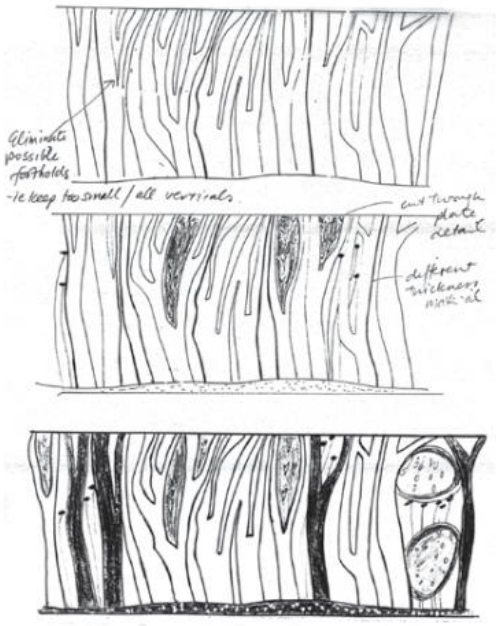
DEFINING THE SITUATION

There is generally no written design brief; communication will be through talking and some quick sketches. Jacki usually presents four to eight ideas (sketches by hand), as design options for the client to choose from. With client input, she will refine one of the ideas or create a solution by combining several aspects of different ideas.

USING NATURE AS INSPIRATION

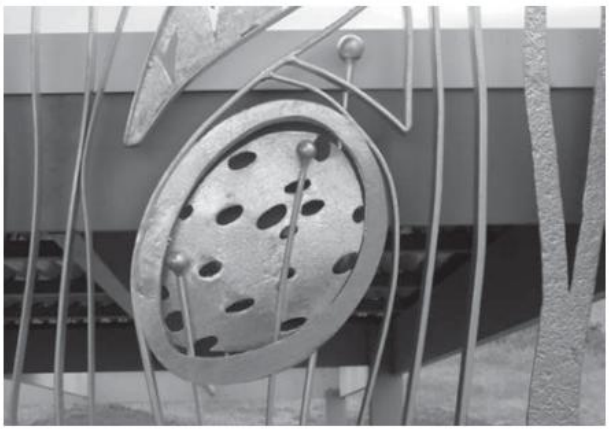
Jacki likes to take the environment or surroundings of the place where her work will be installed into consideration when creating a solution, and aims to include some related visual aspect. On a project with students at a Melton secondary school, microscopic images of plant cells were used to develop shapes. These shapes were then laser-cut into mild steel and layered up to create a 3 metre-tall sculpture.

When designing the balustrade of a new house, Jacki was inspired by the lines and shapes of the surrounding Billy-button grasses.



Jacki Staude

Preliminary drawings for the balustrade of a new house



Jacki Staude

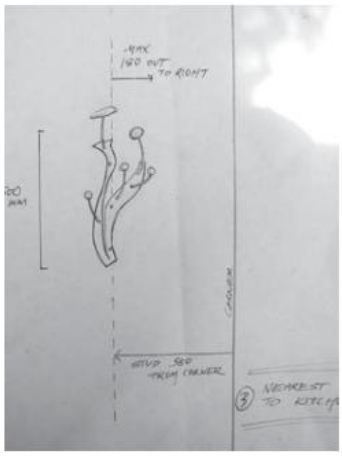
Balustrade detail, showing the Billy-button design

9780170400336

Jacki also had to think about the safety aspects of designing a balustrade for use in a house with young boys. This meant no sharp edges to snag clothing or body parts, and making the spaces too narrow for feet to fit comfortably so that there were 'no footholds' for climbing.

When designing a number of coat hooks for a client, Jacki sought to introduce soft, organic lines and forms into a rather crisp, new house. The client was keen for the work to be personal, with character.

All photos this page courtesy Jacki Staude



Preliminary drawings for some vertical coat hooks

Some of the finished coat hooks, made from mild steel

Jacki inspects some of the finished coat hooks in her studio

One end of the horizontal coat hook

The other end of the horizontal coat hook

However, the visual environment is not the only factor that contributes to the design. Jacki might wander through her collection of odd bits and pieces of metal to see how they could contribute to the design.

In terms of sustainability, mild steel is ideal. When seeking this material, Jacki starts either at her 'collection' or at scrap metal yards, sometimes known as recycling yards. She is armed with a digital camera and a ruler so that she can choose scraps of a suitable dimension, rather than guessing or relying on her visual memory of sizes.

In the past, a metalworker like Jacki could fossick through these yards, but this is more restricted now due to safety regulations.

One of the great things about steel is that it can be used over and over again. When cleaning up her workshop, Jacki gathers any scrap steel and takes it back to the recyclers, where it can be reformed. There is very little waste in Jacki's workshop, as smaller pieces can always be reused. The only issue is storage space and keeping the collection relatively organised.

9780170400336

Some of the 'found objects' that were incorporated into the coat hooks were steel balls from a cement milling factory. Other recycled components can also be inspiring, and in Jacki's collection she has various metal discs, spheres, mesh and other configurations that can be used as they are, joined to other pieces or reformed as needed.

PLANNING AND WORKING DRAWINGS

To create a working drawing, Jacki will draw the chosen design to scale on a drawing board. She usually draws up a 2D scale drawing or provides plans, elevations and a site sketch. The drawings are sent to the client by email or in person, along with a quote. Jacki likes to wait until she has received a deposit – usually one-third of the total cost – before starting on the project.

The mild steel is measured and marked out, ready to be cut

Steel shapes are cut out

Holes are drilled and the hooks are placed, with reference to the working drawings

Details of the placement, with reference to the working drawings

When designing the coat hooks, there were several dimensions to be taken into account: the sizes of the 'balls' that the clothing would be hooked on; the length of the 'stems' and how far the knobs protruded – so as to be safe when people moved past them; and the clearance distance from the nearby doors, so that they didn't bang into the hooks or squash hands.

PROCESSES

The base of the coat hooks was made from 6-millimetre mild steel and their shape was cut out with oxyacetylene. The steel balls (from Jacki's collection) were welded to the stems. Holes were drilled into the steel base, and the stems were placed in the holes and then welded on the back for extra strength.

All photos this page courtesy Jacki Staude

9780170400336

To 'finish' the steel, it was washed with a mixture of acid – usually vinegar – and water, rinsed off and left to dry. This speeds up the rusting of the surface, which can then be wiped off and polished with oil or wax, or stabilised using a rust-converting solution. This is a good finish for interior use and protects clothing from being stained.

For exterior use, one of the coat hooks was galvanised so that the steel wouldn't rust the wooden support where it is attached, nor would it stain the clothes.

Jacki works mainly in mild steel. The processes she does herself are welding, forging, plasma-cutting, rolling and oxyacetylene cutting. The processes that she outsources are laser cutting, larger forging jobs, galvanising, metal spinning (making discs), rolling tubes or plates, and engineering if required.

Laser cutting is used for multiple components, holes for bolts or screws, or for making staggered holes/slots for folding or scoring. It saves a huge amount of time when compared with doing these processes by hand, it can easily accommodate the shape of other components and is excellent for complicated projects. However, one of the problems of outsourcing is the time spent waiting for processes to be completed, as this can be a little unpredictable.

INSTALLING PIECES

When a piece is finished, Jacki usually installs it herself or with the help of her husband and business partner Alistair; one of the problems when installing giant-size works is lifting the huge pieces onto the vehicle for transport.

THE FINAL WORD

Jacki's workshop is in an industrial area in North Shore, Geelong. It is peppered with works in progress, including some giant-size structural pieces on the floor and small decorative bits on benches waiting to adorn them. Jacki is careful to follow all safety guidelines. She keeps the workshop tidy to avoid tripping or other accidents.

She is very careful to protect her eyes, ears, lungs and feet, and tries to wear gloves as much as possible.

You can see more of Jacki's work at her website. A link has been provided at http://nelsonpdtvce.nelsonnet.com.au.

Jacinta O'Leary spoke to Jacki Staude at her workshop in North Shore, Geelong, in 2006, 2010 and, briefly, in 2017.

CASE STUDY

CASE STUDY: Marcos Davidson – jewellery and other products

Marcos Davidson studied gold and silversmithing at RMIT, concurrently training as an apprentice jeweller for the Melbourne jewellery company Select Jewellery. The owner of Select Jewellery, Laslo Puzsar, was one of the founders of the RMIT gold and silversmithing course. At Select Jewellery, Marcos was under the watchful eye of 35 master craftspeople from all over the world. This was a classical training based on rigorous discipline and the honing of skills in time-honoured methods.

Marcos started his jewellery career in 1979, making bespoke/custom jewellery, architectural furniture (doors, door handles, light fittings, fittings for interiors) and **hollowware** for table service.

hollowware metal tableware or articles that serve as containers or vessels

Marcos working on jewellery

9780170400336

DESIGNING

'Making jewellery is micro-engineering,' says Marcos. 'I have to think about how a catch or clasp will work, how dangling bits might interfere with the wearer or the rest of the piece, and how something will hang and all the safety and quality aspects associated with this. To sum it up, I cover metallurgy, gemmology and engineering.'

To find out more about gems, go to the Gemmological Association of Australia website. A link to this website is provided at http://nelsonpdtvce.nelsonnet.com.au. You will also find many coloured pictures of Australian gems: select 'Australian gem gallery'.

Marcos' jewellery differs from the work of others, where pieces are polished to perfection, are precisely symmetrical and the jeweller's tool marks cannot be seen. On Marcos' work, the tooling marks are evident and the forms are not mathematically precise, yet the techniques are of solid quality – they are made to 'wear in' and not 'wear out'. Each piece is a showcase of his thorough training in traditional methods, but speaks clearly of contemporary culture and style.

HALLMARKS FOR AUTHENTICITY

An important guarantee of quality and authenticity for any jeweller is a **hallmark** – the oldest form of consumer protection. Marcos has hallmarks for the maker (himself), the locality (Melbourne), the workshop (when others have been involved), the metal content (purity and quantity) and the date. His hallmarks are stamped on the underside or inside of a piece of jewellery; in the case of a chain made of **palladium**, every link is stamped.

hallmark
a mark stamped on precious metals to identify the purity of the metal, the maker, the place, etc.

palladium
a rare silver-white metal

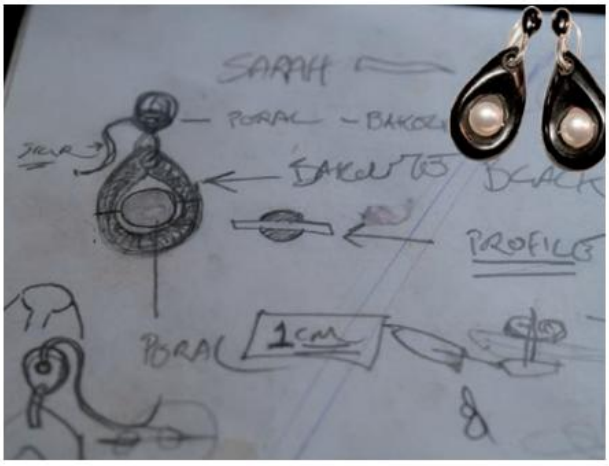
Each link in a chain of palladium is hallmarked

Hallmarks on the underside of a brooch

INSPIRATION AND THEMES

Marcos' themes are masculine, and the finished forms are robust and organic, with an ancient flavour. He describes his work as 'refined, but made with some abandon'.

Inspiration comes to him from his daily life and personal interests. He does extensive research on themes, such as reading about an era, and studying configurations of plants and particular characteristics of animals, e.g. the number of petals in particular flowers, the number of legs on a squid and how the legs join the body. This is essential as a lot of imagery in Marcos' work aims to be representative – not abstracted – so that it's easy to identify the original reference or object of inspiration.



A pair of Bakelite and pearl earrings, with schematic drawings

9780170400336

Through research, Marcos learned of an observation technique that some Japanese artists used to diffuse the light: squinting. By partially closing their eyes they were able to see dark and light areas more easily; to get the proportions and silhouette of an object without the clutter and detail.

Marcos' training, knowledge and confidence with skills and materials, combined with this research, informs any new development of ideas. An example of this is a belt buckle that clearly represents a surfboard, yet at the same time requires 'engineering' to ensure that it is functional. Marcos will have a preconceived vision of the finished object, and this includes the 'backwork' of devising methods and procedures to create it.

In dealing with clients Marcos prefers the **'bespoke'** method, where the client 'speaks' about what they want. Some **schematic drawings** are sketched up and, when the client is happy, the work starts.

bespoke
made to order

schematic drawings
diagrams showing the scheme, similar to visualisations

Marcos will often make a collage that includes shapes, forms, lines and textures related to the theme. The collage will be a reference point and include research items, some drawings, notes and measurements, and a 'benchmark'. The benchmark may be a line length marked out on the collage, which will be the required length of the bracelet or necklace being made. It allows him to lay out all the components – e.g. chain links, clasp and gems – along the line to check their length in total and adjust accordingly.

A collage of research and ideas related to a squid-inspired necklace

Due to the special nature of the pieces and the preciousness of the materials, a sample or maquette is often made up in brass or silver first. This helps to get the right size for the client (who may have up to four fittings). It also helps with quantity surveying – i.e. weighing the sample and doing the maths to calculate the amount of precious metal needed – and with costing.

A silver maquette sits on the right; the gems are set upon clay on a 'benchmark' to help with the layout for the gold ring on the left

A ring of palladium, sapphire and other gems, with a similar layout

9780170400336

An opal and white gold ring in the making

PRODUCTION AND MATERIALS

All of Marcos' pieces are 'one-offs', and normally all work is done by hand. Occasionally, work is cast to make batches of components, such as buttons and door handles.

One of the materials Marcos uses is bakelite, a thermosetting plastic, developed in 1900, that was the world's first three-dimensional man-made material. Being non-conductive, its first use was as an insulator; now it is commonly used in electrical and mechanical engineering. He also specialises in working with all gemstones and metallurgy (**alloys** of gold, platinum and silver).

alloy mix of metals

A commission from a restaurant for water jugs (hollowware) required some inventive techniques. The client wanted the jugs to be striking, suitable for water, large but lightweight. Stainless steel sheet was the material. The seam needed to be TIG welded: this was outsourced to fabricators. To twist the handles required an assistant, due to the tensile nature of the metal. Some experiments helped to calculate the correct length of the tubing, as the twisting shortened it markedly and could occur irregularly along its length. The jugs were

Twisting the handles

Maquette of jug to calculate handles

Pinning the handle for placement in comparison to the maquette

Holding the jugs steady for interior sanding

Finished jugs

9780170400336

planish
to shape, smooth and flatten with a hammer or between rollers

mandrel
a rod around which metal is forged or shaped

anvil
heavy (usually metal) block on which to strike an object

planished (hammered over a steel **mandrel** and the horn of an **anvil**) to get the inside surface smooth and clean; to prevent the jugs rolling around he set them in a jig and strapped them up with a leather sand cushion. Then back to the fabricators for TIG welding of the handles and the base to the body.

MANAGING MATERIALS

Pieces are made entirely by hand and need to be crafted (ground and carved or 'cut', as in gem cutting). Minimising dust from any materials, such as metal, wood, bone or shell, is important. When grinding or polishing bakelite, water is dripped or run over the sanding wheel and collects in a tray.

Any sweepings, off-cuts or scrapings of raw metal particles are sent to metallurgical refiners or metal reclaimers for further separation and extraction. This makes good use of the waste, which can be melted together in a crucible to cast a new ingot. The ingot can be rolled like a pencil, stored easily and reused in new pieces of jewellery.

MARKETING OR GETTING KNOWN

Most of Marcos' work comes through word of mouth. This is an unusual situation, as most jewellers work for a company or supply specific retail stores, where they may be working on their employer's designs.

There is a long process involved in setting up, creating one's reputation and establishing reliable lines of communication. To gain 'word of mouth' it is important to have a 'real' or 'virtual' showcase of work. In Marcos' case, this includes:

- Instagram to reach prospective clients {augusto.davidson} with hashtag #marcosdavidsonjeweller
- a residency at Craft Victoria
- exhibiting in private contemporary art galleries and boutiques
- creating work for local government – Melbourne City Council city gallery and NGV Melbourne.

All of this gives a wider exposure to his practice, bringing customer referrals.

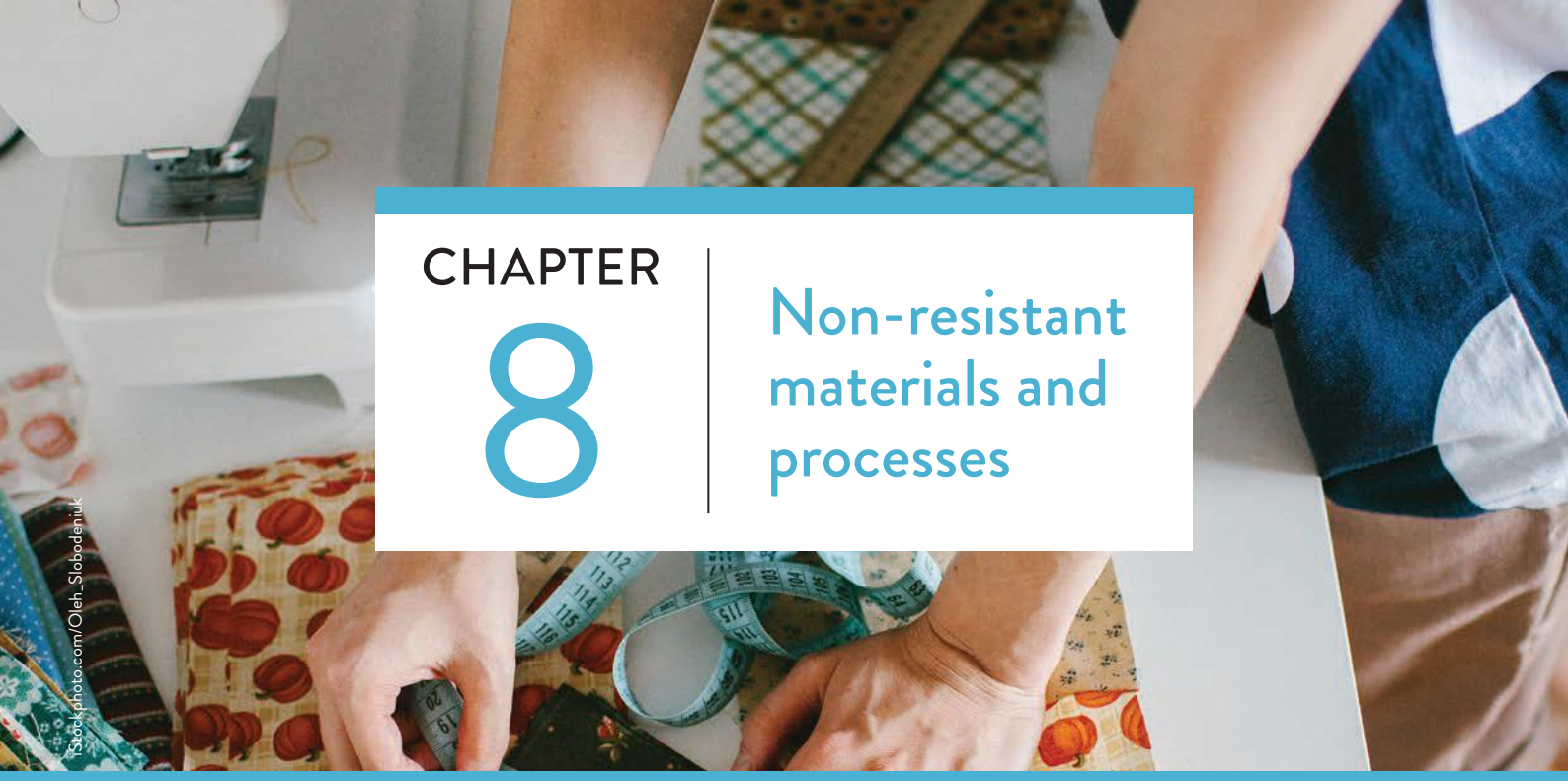
Working towards an exhibition or installation gives a designer a finished body of work that can then be photographed and used in brochures and grant applications. This is an important aspect of being a self-employed artisan. A website allows prospective clients and overseas buyers to get an overview of his work, products, materials, press articles, and how the workshop operates. Clients often bring images from his website when commissioning a work as a reference for what they would like.

Marcos Davidson spoke to Jacinta O'Leary in February 2017.

To see more of Marcos' work go to his website. A link has been provided at http://nelsonpdtvce.nelsonnet.com.au.

Ganoskin is a thoroughly extensive website on jewellery. This site has information on all aspects of jewellery making, such as health and safety, tips and techniques, gemmology, suppliers and information on metals. A link has been provided at http://nelsonpdtvce.nelsonnet.com.au.

9780170400336



iStockphoto.com/Oleh_Slobodeniuk

CHAPTER 8 Non-resistant materials and processes

CHAPTER FOCUS

In this chapter you will learn about:

- Properties of textiles – including the classification, properties and uses of fibres p. 214
- Fabric production and properties – including forms of fabric, fabric construction and fabric finishes p. 218
- Issues related to textiles – including health and safety, quality and environmental issues p. 222
- Processes for fabrics, fibres and yarns p. 224

Through case studies (p. 238), you will also discover how designers work with textiles.

PROPERTIES OF TEXTILES

The general heading 'fabrics, fibres and yarns' covers all of the elements of the textiles area, including:

- natural and synthetic fibres, filaments and yarns
- woven, knitted, tufted, braided, bonded and embroidered fabrics
- non-woven fabrics, consisting of mechanically and chemically bonded fibres (e.g. felt and medical dressings).

Textile fibres and fabrics have an extremely broad range of properties. Some fibres are efficient conductors of heat, transferring heat away from the body quickly (e.g. cotton). Others are good insulators, keeping hot or cold air trapped (e.g. wool, silk). Some fabrics are hydrophobic and don't absorb moisture (e.g. polyester, acrylic). Others absorb moisture very effectively (e.g. cotton, viscose). Synthetic fibres (such as nylon and polyester) have good strength characteristics, while natural fibres (such as wool and mohair) are weak in comparison.

The strength and directional properties of a fabric are directly related to its method of manufacture. Knitted fabrics tend to be stretchy and flexible, woven fabrics are stronger and less stretchable, and some non-wovens are stiff and even less stretchable in comparison.

9780170400336

Fibre classification

The two main categories of fibres, natural and synthetic, relate to the source of the fibre:

- Natural fibres occur, ready be to processed and used, in their natural form. They can be split into two further groups:
  - those coming from animals (protein)
  - those coming from plants (cellulose).
- Synthetic (or manufactured, man-made) fibres can also be broken down into two further groups:
  - regenerated fibres, which are based on a natural fibre that has been chemically altered
  - fully synthetic fibres – fibres that are created during the processing stages.

Types of fibres

Natural	
Protein	Cellulose
Wool	Cotton
Mohair	Flax
Angora	Hemp
Silk	Jute
Alpaca	Linen

Synthetic	
Regenerated	Fully synthetic
Rayon	Nylon
Bamboo	Polyester
Cupro	Acrylic
Polynostic	Modacrylic
Acetate	Lycra

When describing the **length** of fibres, two terms are commonly used:

- **filament** – a continuous length of fibre, e.g. silk and most synthetics
- **staple** – naturally occurring or cut lengths of fibre, from very short to long, e.g. cotton (short) and flax (long).

The physical structure of a fibre has an effect on the fibre's properties and appearance, e.g.:

- **Woollen fibres** have an overlapping, scale-like structure, which increases their insulating quality and their tendency to felt. They have a soft, non-shiny appearance.
- Most **synthetic fibres** have a very smooth shaft, which increases the lustre or sheen of fabric made from those fibres, as the fibre is uniform and reflects light.
- **Microfibres** are fine synthetic fibres. They have distinct characteristics: they are less absorbent and have a wicking quality (i.e. they draw moisture from the body); fabric made from these fibres can have a higher density, and has greater drapability and softness.

Fibre blends

Some fibres are **blended** to combine fibre characteristics, or to overcome weaknesses. For example, most T-shirts, windcheaters and sheets are made from poly-cotton (a mixture of polyester and cotton), as product manufacturers want to combine the strength, wrinkle recovery and fade resistance of polyester with the moisture absorbency of cotton fibres.

blended different fibres are spun together to form a thread or yarn

9780170400336

Fibre properties, uses and forms

Name	Identification	Properties	Uses	Available forms
Wool	• Short to long staple length • Fine to coarse • Usually soft • Warm to touch	• Thermal insulator • Water-absorbent • Weak • Flame-resistant • Moderate cost	• Clothing, outer wear • Blankets	• Knitted and woven • Non-woven felt • Yarn
Silk	• Continuous filament • Fine • Usually soft, warm to touch • Sheen	• Thermal insulator • Water-absorbent • Weak • Flame-resistant • Wrinkles • Expensive	• Expensive clothing and accessories	• Woven and knitted • Yarn
Cotton	• Short fibre/staple length • Soft • Fine • Cool to touch	• Thermal conductor • Water-absorbent • Strong • Wrinkles • Low cost • Loses colour	• Clothing, sports wear • Manchester • Packaging • Medical uses	• Knitted and woven • Non-woven wadding • Yarn
Flax/linen	• Medium sheen • Cool to touch • Very long staple length • Increased softness when washed	• Very strong • Absorbs water • Wrinkles easily • Strong, but wears on folds, hemlines, etc. • Absorbs moisture without feeling wet	• Bed linen, manchester • Expensive clothing • Good for hot climates	• Mainly woven fabric
Acetate	• Continuous filament • Fine • Medium to soft feel • Sheen	• Weak • Fair water absorbency • Wrinkles • Burns and melts with heat • Low cost	• Clothing, linings	• Usually woven
Bamboo	• Long or continuous fibre • Silky • Soft lustre • Soft drape	• Absorbent – draws moisture from skin • Breathability • Antibacterial • Durable and strong • Dyes easily • Environmentally sustainable alternative	• Underwear, sportswear, knitwear • Non-woven – nappies • Surgical/ sanitary applications	• Woven and knitted yarn • Non-woven/bonded
Polyester	• Continuous filament • Can be made fine or coarse • Medium to harsh feel (but microfibre is soft)	• Thermal insulator • Very strong • Wrinkle-resistant • Water-resistant • Burns and melts with heat • Colour-fast	• Clothing • Manchester (in blends) • General purpose	• Woven • Knitted • Melt-felted for medical uses
Nylon	• Continuous filament • Can be made fine or coarse • Medium to harsh feel	• Thermal insulator • Very strong • Wrinkle-resistant • Water-resistant • Burns and melts with heat • Colour-fast	• Clothing • Waterproof clothing and covers • Bags • Industrial uses	• Woven • Knitted • Yarn and rope

9780170400336

Fibre processing

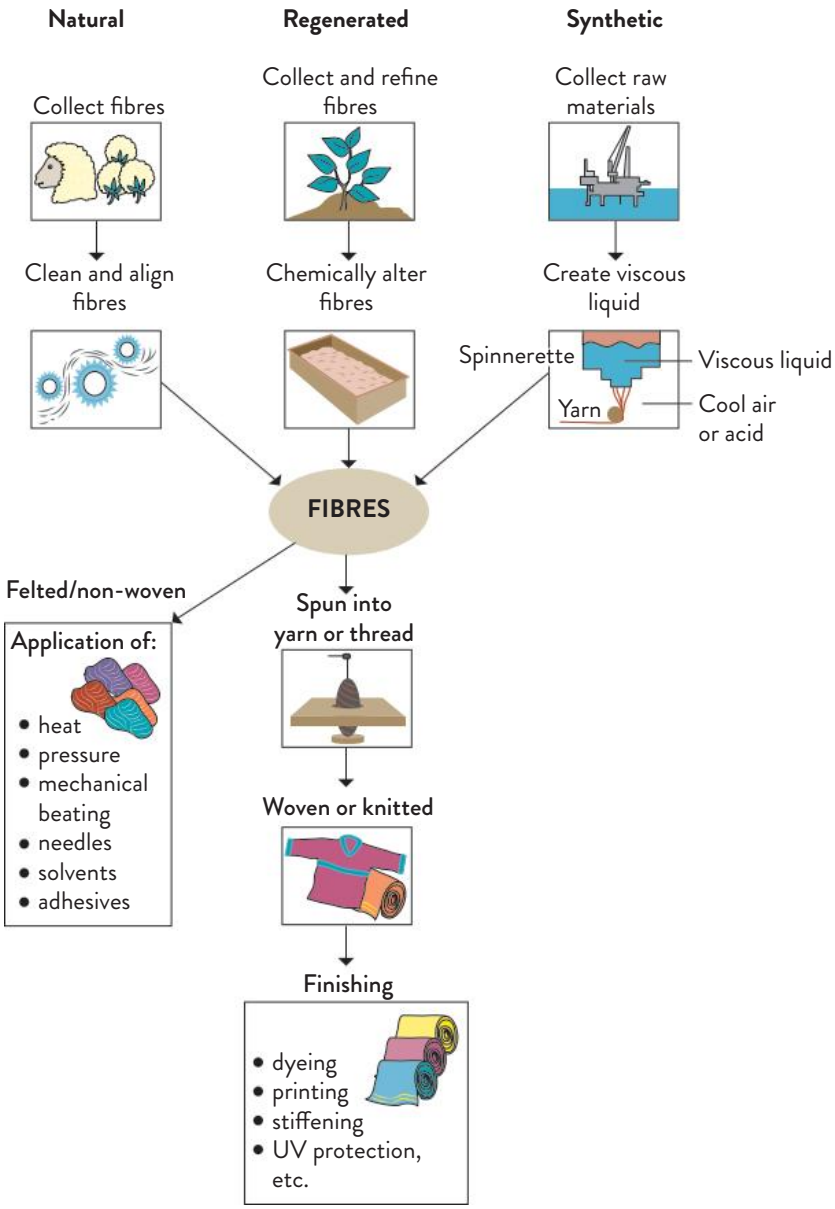
Natural raw fibres – such as cotton, wool and silk – must be processed and made ready for the spinning plant:

- Cotton is put through a **gin** to remove seeds and other impurities, before being baled for the spinning mill.
- Wool fibres go through scouring and carding processes to remove some of the larger impurities and to align the fibres.
- Continuous filaments, such as silk, are unwound and gathered together to form multi-filament yarns in a process known as throwing.

gin
a machine that separates seeds and impurities from fibres

To make **regenerated fibres**, naturally occurring fibres from trees and plants are chemically altered to give them strength and flexibility.

Synthetic fibres or **filaments** are made by combining chemicals into a viscous liquid. The liquid is then forced through a **spinnerette** (a plate with fine holes), and the stream of liquid is hardened into a filament by the action of acid, or warm or cold air.



A fibre production flow chart

9780170400336

Yarns

The degree and type of twist can affect the properties of the yarn and the fabric it is made into. Yarns are usually hard or soft spun.

- Hard-spun yarns have a tight twist (e.g. the strong warp thread of gabardine).
- Soft-spun yarns (and the resulting fabric) are more absorbent, more flexible and have good wrinkle recovery. Examples of the use of soft-spun yarns are woollen fabrics, fabrics with a nap, knitwear and knitting yarn, and brushed fabrics.

Fancy or novelty yarns use threads of differing thickness and tension in construction, and can be heavily textured.

Skins and membranes

Skins such as leather and sheepskin are hard to categorise in the textile area. They are used like a fabric but are not constructed. Membranes such as latex and rubber are also used like a fabric.

jacquard
small repetitive patterns knitted into a fabric, often with different colours

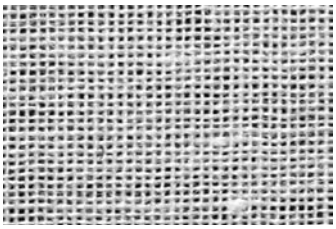
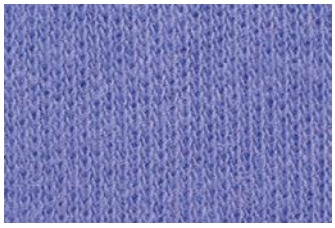
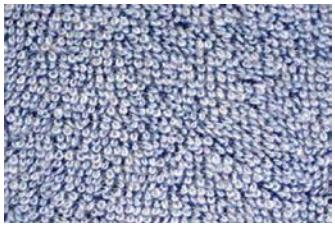
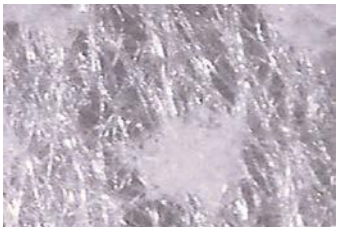
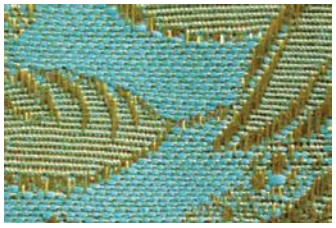
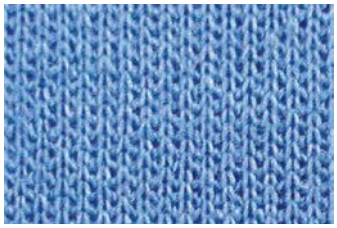
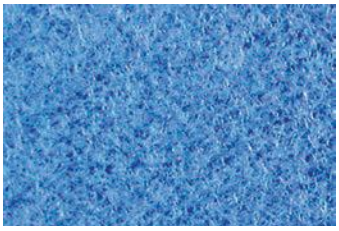
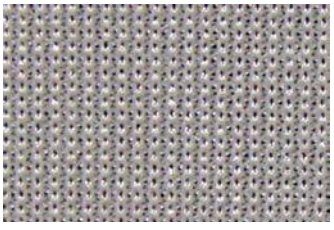
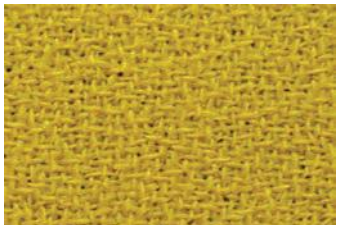
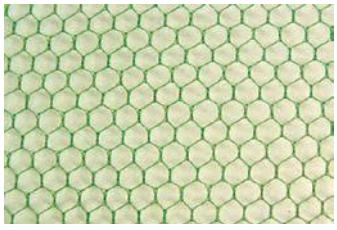
FABRIC PRODUCTION AND PROPERTIES

Properties and forms

Fabric type	Appearance	Properties	Different forms and uses
Woven	Usually an even, grid-like appearance: under/over pattern of threads	Tightly woven fabrics are very firm and strong Loosely woven fabrics are relatively flexible	Basic weaves: • Plain – a simple, alternating woven pattern (e.g. sheeting and linen) • Twill – strong diagonal pattern in the weave (e.g. jeans) • Satin – with a sheen (e.g. clothing, curtains, upholstery) • Compound – dobby, **jacquard** (e.g. curtains, upholstery) Leno or gauze: interlaced warp yarn (e.g. translucent curtaining) **Pile**: extra yarn looped in warp/weft (e.g. terry towelling, velvet, velveteen)
Knitted	Looped threads; can have a smooth, textured or ribbed appearance	Stretchy, flexible; firmness dependent on the tightness of the knit	Weft – derived from hand knitting **Basic**: plain, purl, ribbed **Double**: interlock, double-knit General uses: clothing, sportswear Fine elastic fibres used for hosiery
			Warp – by complex machines **Tricot**: used for linings and underwear **Raschel**: lace, mesh, intricate, pile – used for food bags, lace tablecloths, curtaining
Non-woven	No thread, uniform construction, matt appearance	Thick: very firm, stretch-resistant, insulating and waterproof Thin: flexible and absorbent	Can be matted together using the properties of the fibre (wool) or by thermal, physical or adhesive bonding Thick: used for hats, floor coverings, industrial uses Thin: used for disposable cloths, filters, medical uses
Stitch-bonded	Thread-like layers one way and stitching or chains the other way	Variable, depending on fibre and construction density	**Mali**: layers of different yarns (usually fancy) are stitched through – used for furnishings Fibreglass and structural reinforcement: used as a strengthening core for resin-based forms and structures

9780170400336

Fabric construction

Woven	Knitted	Non-woven
 Plain weave – organza	Single-knit	Felt
Twill – denim	 Interlock	Chemically bonded fabric
Crepe-back satin	 Knitted terry cloth	 Thermo bonded fabric (interfacing)
 Jacquard	 Fleecy	 Fleecy – wrong side
Pile weave – crushed velvet	 Tricot	Looped needle-punched fabric
 Crepe weave	Knit lace	 Tulle

9780170400336

Shutterstock.com/kavring

Shutterstock.com/Ionia

Products made from felted fabric

Fabric finishes

Finishes affect the appearance and the properties of fabrics. There are two main categories of fabric finishes: mechanical and chemical.

Mechanical finishes	Chemical finishes
Pressing (e.g. chintz)	Burnt-out (Devore) – either chemically burnt or laser cut
Embossing (thermal patterning)	Parchmentising (stiffening, e.g. organdie) or starching
Napping	Additives for serviceability – flame-retardant, water-resistant, permanent press
Brushing	UV protection
Fabric decoration through stitching	Printing and dyeing

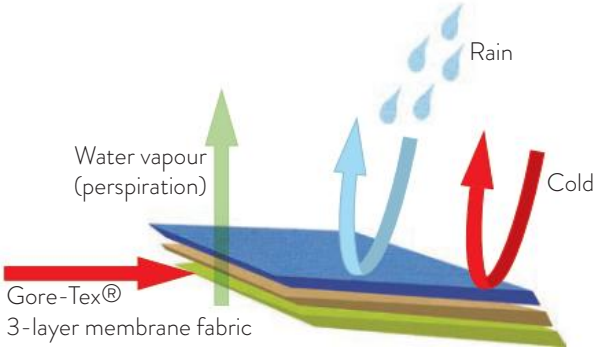
Fabrics with special characteristics

Laminated or bonded fabrics

To create a laminated or bonded material, fabrics of different physical characteristics or fibre content are bonded or fused in layers. Many high-performance sports fabrics have been developed after research into the needs of the body during intense activity in different environments. Examples of laminated fabrics include Gore-Tex®, Sportwool® and Mexican oilcloth.

For information about how Gore-Tex laminated fabrics work, go to the Gore-Tex website and scroll through 'Discover our technologies'. A link to the website has been provided at http://nelsonpdtvce.nelsonnet.com.au.

Gore-Tex uses a breathable membrane as its central layer. This fabric allows fine particles of water vapour to escape from



Structure of Gore-Tex®

9780170400336

the body, but doesn't allow the rain and damp to penetrate. Waterproof and windproof breathable membranes are used in jackets, tops, packs, shoes, etc. (Note that Gore-Tex is now out of its patent period, so many similar fabrics are being developed and marketed by other companies.)

Sportwool uses the thermal insulation of wool next to the skin and the wicking qualities of synthetic fibre on its outer surface. This fabric keeps the wearer warm before and after exercise, cool during exercise, and also reduces the feeling of sweatiness by keeping the skin dry.

Find out more about sportwool by going to the CSIRO website, and search for either 'sportwool' or 'CSIROpedia'. A link to the website has been provided at http://nelsonpdtvce.nelsonnet.com.au.

Mexican oilcloth is a waterproof fabric that was originally coated with linseed oil, but is now mostly layered with a printed PVC coating. It has become very popular for a range of handcrafted products due to its vibrant colours and creative prints.

Smart yarns

Smart yarns are constructed from hollow fibres that are filled with chemical substances. Fabrics constructed from these yarns are primarily used for:

- pharmaceutical purposes – for protecting the skin, distributing medication to the skin (e.g. nicotine patches), drawing contaminants away from the skin, and sensing biomedical conditions
- children's clothing – the hollows may be filled with synthesised fragrance (e.g. chocolate or banana) to make the clothing more appealing.

For more information about new developments in fibre technology, go to the CSIRO website and search for 'textiles and fibre technology' or 'advanced fibres'.

Smart electronic fabrics: wearable technology

Smart electronic fabrics have electronic components incorporated into the structure of the fabric. Examples are:

- clothing for high-performance athletes – fabric that monitors heartbeat, tracks movement, etc.
- electronically heated fabric
- fibres that monitor blood health
- solar collector and device powering.

Hardware and software that run or monitor the smart components are developed together as an integrated system.

A 'smart yarn' has been developed that uses carbon nanotubes. The yarn can conduct electricity and heat, and is strong enough to protect the wearer from bullets. For more information, go to the *Science Daily* website and search for a recent article on 'smart yarns'. A link to the website has been provided at http://nelsonpdtvce.nelsonnet.com.au.

Edson Hong

The MyZone sports bra, which monitors heart rate and calories burned. It works with the MyZone app, earning the owner effort points as fitness improves.

9780170400336

ISSUES RELATED TO TEXTILES

Health and safety issues

There are a number of health and safety issues related to the production and use of textiles. Farmers and workers tending and harvesting fibre crops on which a lot of fertilisers and/or pesticides have been used often suffer multiple health problems. Health concerns related to textiles also occur during the yarn and fabric production stage, where chemicals (for cleaning, degreasing, dyeing, etc.) and heavy machinery are used extensively. During manufacture, hazards range from the chemicals used in further dyeing, treatments to 'distress' denim, fumes from heat-sealing joins in synthetics, unsafe factory buildings, long working hours and the machines used in construction. Of course, if the textiles article is large enough, e.g. a yacht sail, there is also the potential for lift-associated injuries to occur. There are also health risks associated with the 'off-gassing' of volatile organic compounds (VOCs) from some fabrics and fabric treatments.

Refer to pages 39–43 for details of risk assessment and identifying and controlling risks related to materials and machinery. There are specific standards relating to textiles. Refer to page 112 for information on standards.

Quality of materials

The quality of a natural fibre depends on the circumstances under which it was grown (e.g. the quality of wool depends on the sheep's breed and the care of the sheep, as well as the climate).

For all fabrics, the quality and functional characteristics depend on the quality and properties of the original materials, and the quality of processing during manufacture. For instance, the quality of dye used and the physical characteristics of a fibre affect colour fastness, while the tightness and evenness of weave or knit and the strength of a fibre will influence resistance to abrasion and stretching.

Environmental issues

Many people feel that natural fabric and fibres are fairly benign in their impact on the environment. However, the pesticides used in the production of cotton have a significant environmental impact (even though the amount of pesticides has been reduced in the last 10–15 years). Cotton production uses about 2.8 per cent of the world's fertile land; but 6.8 per cent of the world's use of pesticides and 16 per cent of the world's use of insecticides is on cotton crops.

marginal land land that is of poor quality and may be fragile

In Australia, **marginal land** that is used for raising sheep for wool production has been irreparably damaged. On the other hand, the production of synthetic fibres uses petrochemicals and other non-renewable materials, and produces pollutant by-products during processing.

The use of synthetic fibres in fabric also creates environmental problems. Synthetic fibres are predominantly made from non-renewable petrochemical resources. Regenerated fibres are made from cellulose fibres that are chemically changed. Both deplete the world's resources and create waste and pollutants during production. A significant issue is the problem caused by the disposal of clothing after it is no longer useful or wanted. Clothing made from synthetic fibres takes thousands of years to break down in landfill, causing a rapidly increasing problem. As clothing becomes cheaper to buy and is driven by a shorter fashion cycle, more is thrown away before being worn out. Even clothing made from natural fibres takes a long time to break down in an airless (anaerobic) landfill environment.

9780170400336

Some moves have been made to lessen the impact of textile production. Cotton plants have been genetically modified to make them resistant to insects and disease, reducing the need for chemical sprays (although genetically modified cotton also has its own problems). The demand for and production of organic and sustainably produced cotton is steadily growing and can now be certified through:

- Global Organic Textiles Standards (GOTS)
- Fairtrade certification.

Another form of textiles certification is Oeko-Tex® Standard 100, a standard that indicates that the textile product has been tested and is free of harmful levels of chemicals (e.g. dyes, finishes) and is safe for human use (Standard 100, certified by the independent international Oeko-Tex organisation).

OEKO-TEX®
CONFIDENCE IN TEXTILES
STANDARD 100

Oeko-Tex®

Hemp, bamboo and soybean fibre are increasingly being used to replace cotton, as their growth is more environmentally friendly. However, bamboo and soy have their own environmental impacts due to clearing of forests and the processing required to turn them into fibres. Bamboo fabric is essentially stiff and rough, unless treated with chemicals to turn it into a rayon, which is the most common form used for clothing. Fabrics such as the original Polartec polyester fleece reduce waste, as 60% of the fibre used is sourced from recycled plastic drink bottles. However, on the down side, this fleece sheds millions of microfibres into waterways when washed. *Refer to page 125 for information on environmental design strategies relating to textiles products.*

For information on the environmental problems related to the production of cotton, search for 'sustainable cotton', 'organic cotton' or 'cottoninc'. Links to Organic Cotton and Cotton Incorporated and the other websites mentioned on this page are at http://nelsonpdtvce.nelsonnet.com.au.

For a discussion of environmental issues related to clothing, search for 'waste couture' and 'fast fashion' and read the most recent information.

For specific information about the environmental issues related to particular fibres, go to Green Choices, 'Environmental impacts'.

For the Textiles and Fashion Eco-Design 'Quick Guide' of strategies for eco-design, and the pros and cons of different fibres, go to the DATTA Vic website and search for 'textile and fashion eco-design'. For information about environmentally friendly materials in the outdoor clothing market, Patagonia has developed a library of materials and their impacts.

The EcoTextile News is an environmental magazine for the global textiles supply chain. Articles are on a wide range of topics.

Shutterstock.com/rj lerich

Outdoor clothing can be made from fleece with recycled PET (polyethylene terephthalate) content

PROCESSES FOR FABRICS, FIBRES AND YARNS

A range of production stages needs to be completed when constructing a product made from fabric, whether it is clothing, accessories (hats, bags, shoes, etc.), furnishing, covers or containers. These stages contain a variety of processes. Some of the major stages are:

- measuring
- making a toile
- pattern alteration and/or modification
- pre-washing fabric
- pattern layout
- cutting and marking
- joining
- insertions and additions
- finishing and edging
- decorative processes.

Most of the information that follows will relate to the production of clothing, but many of these stages can easily be transferred to the production of other fabric products.

The Textinfo Textiles Hub website has a great glossary of textiles tools and definitions of textiles construction terms. A link to the website has been provided at http://nelsonpdtvce.nelsonnet.com.au.

Measuring

To make a successful product that fits well, it is important that accurate measurements are taken. For products other than clothing, the measurements needed depend on the situation; if you are making a loose cover for a sofa, for example, you will also need to take specific and accurate measurements.

For clothing, there are standard measurements that you need to record. The measurement table on page 227 is fairly extensive – you won't need all of these measurements for every garment. However, even when you are using a commercial pattern, you will need further measurements than the basic three (bust/chest, waist and hips) to ensure that the clothing will fit the individual. These measurements can be used to form a simple pattern block, or to check and modify commercial patterns.

Measuring tools

- measuring tape
- metre rule or yardstick
- L square
- skirt/hem marker

Making a pattern block and pattern drafting

Making a pattern block for an individual and then using that to develop pattern pieces for a garment means that the clothing made should fit well. It also allows the designer/maker to develop a piece of clothing that is individual and suits the particular functional and aesthetic needs of the wearer. Pattern drafting is a complicated process that requires specific training. There are some physical and digital pattern drafting systems available that use templates to allow for individually sized blocks to be created. This simplifies the pattern drafting process.

9780170400336

Making a toile

A **toile** is a fabric trial that ensures the correct fitting of the final garment. Fabric pattern pieces for a toile are usually cut from calico, or a cheaper fabric that mimics the stretch and fall of the fabric chosen for the product. The pieces are tacked together, fitted directly to the body, and the seams are altered for closer fitting. The toile is then used to check the placement and shape of seams, darts, neckline, etc., and how the garment sits on the body; after which the seams are unpicked and the changes are transferred to the 'real' fabric.

toile
a full-sized version of the finished garment made out of an inexpensive fabric, such as calico

Draped pattern making (called 'French draping') can also be done at this stage. Fabric (without any cut pattern pieces) is draped over the body, and pinned or tacked to follow the body shape. It is then used as a guide for creating pattern pieces.

Pattern adjustments

In Units 3 and 4, you may use a commercial pattern as a base, but you are expected to alter it to reflect your own design (your preferred option). Changes can be made to pattern pieces by folding (to reduce a section) or by cutting and inserting extra pattern paper (to enlarge a section). Careful measurements need to be applied to these changes. It is worthwhile constructing a toile with cheap fabric to check that all size calculations and modifications produce the desired effect (before cutting expensive fabric).

Pre-washing fabric

It is important to wash any fabric before cutting. This will remove any starching that the fabric may have, shrink the fabric (if the fabric has this tendency) and remove any excess colour from printing or dyeing.

Pattern layout

All the pattern pieces should be set out on the fabric before cutting. It is important to lay pieces in the appropriate direction according to the grain, and to be aware of the **selvedge edge**. Pattern pieces should be arranged to minimise waste (this is an important cost and environmental consideration in industry).

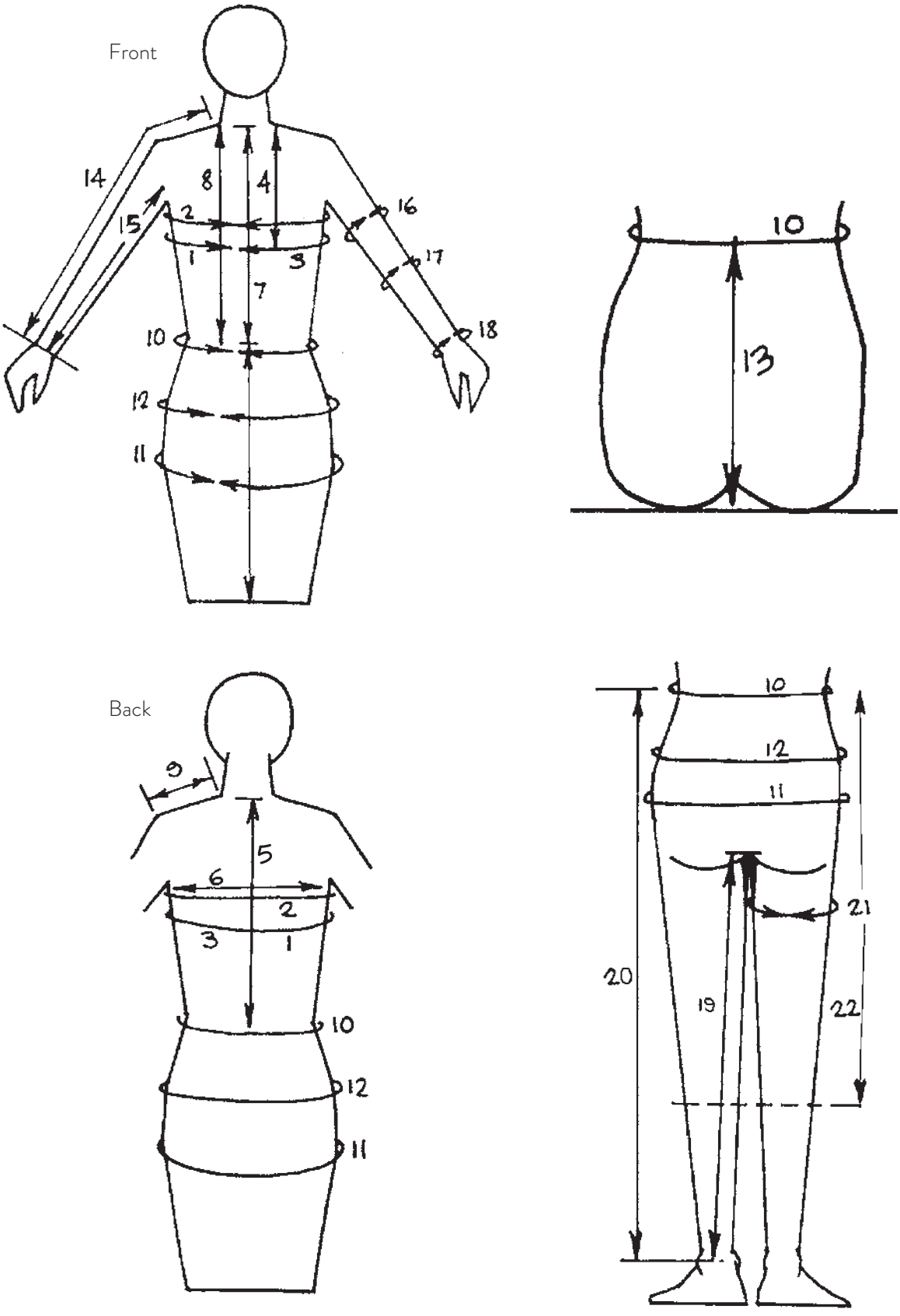
selvedge edge
the rough, unevenly woven or knitted edge of the fabric (usually about 10 mm wide) that keeps it from unravelling

It is necessary to note and make allowances for:

- the right and wrong side of the fabric
- any strong fabric design features (e.g. checks, stripes, large repeating printed designs)
- the nap (the directional texture or pile of the surface of the fabric).

Paper pattern pieces can be kept in place with pins or weights.

9780170400336



Body measurement locations

9780170400336

Body measurement locations

Body section	Description of measurement location	Number on diagram	Your measurement
Chest or bust	Chest – around the largest part of the chest (men, children)	1	
	High bust – under the armpit (women)	2	
	Low bust – around the largest part of the bust (women)	3	
	From shoulder to bust point (women)	4	
Back	From prominent neck bone to waist	5	
	Back width – across back over shoulder blades	6	
Front	Centre front – from base of neck (centre) to waist	7	
	Front length – from side neck to waist	8	
Shoulder	From side neck to shoulder bone	9	
Waist	Above the hips where waist is narrowest	10	
Hips	Low hip – around the fullest part of the hips and bottom	11	
	High hip – over the hip bone	12	
	Hip depth – from waist to chair when seated	13	
Arms	Length – from shoulder bone to wrist over slightly bent arm	14	
	Inside arm – from underarm to wrist	15	
	Around upper arm	16	
	Around elbow	17	
	Around wrist	18	
Legs	Inside leg – from crotch to ankle bone	19	
	Outside leg – from side waist to ankle bone	20	
	Thigh – around the widest part of the upper leg	21	
	Skirt length – from waist to desired length	22	

Cutting and marking

Cutting

The most common tool used for cutting is dressmaking scissors, but a rotary cutter can also be used effectively for some fabrics or for many layers. A large table that is at a reasonable height also helps in the cutting process and reduces back strain. If the pattern pieces don't include seam allowances, it is critical to add these while cutting.

9780170400336

Cutting tools

- fabric scissors
- bent-handled scissors
- pinking shears
- rotary cutters
- electric scissors/ rotary cutters
- seam ripper or quick-unpick

Trotec Laser GmbH, www.troteclaser.com

Trotec's SP300 large format laser cutter

In industry, cutting is highly mechanised, utilising motorised saws or computer laser-cutting benches to cut many layers of fabric swiftly and accurately (lasers have the added advantage of sealing the edges of synthetic fabric).

It is important to be well organised during the cutting stage, keeping sections together and storing them neatly after cutting (to reduce creasing and to avoid confusing the pieces).

Marking

You will need to transfer any significant pattern positions or markings onto the fabric, such as dart shaping, zip or button placement, and the end of seams. This can be done with tailor's chalk, washable markers or tailor's tacks, or by cutting notches.

Marking tools

- tracing wheel
- tailor's chalk or chalk pencils

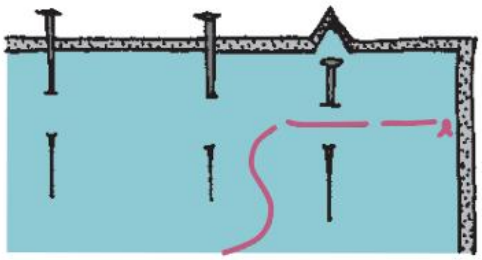
Minor preparation stages

Basting/tacking

basting tacking fabric layers together using loose stitching

Basting or tacking stitches are long straight stitches without reverse or double-stitching at the ends so they can be easily removed.

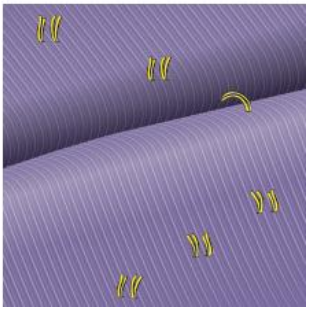
Tacking is used to hold two or more layers of fabric together temporarily, to 'gather' seams, to check fitting, align fabric patterns and pieces or components, such as zips. Basting/tacking can be done either by hand or machine. After the seam is machine-sewn, the tacking thread is removed.



Basting/tacking

Tailor's tacking

Tailor's tacking is used to transfer pattern markings to one or two fabric layers. Tailor's tacking can be more accurate than tailor's chalk and it also has the advantage of not rubbing off easily after handling.

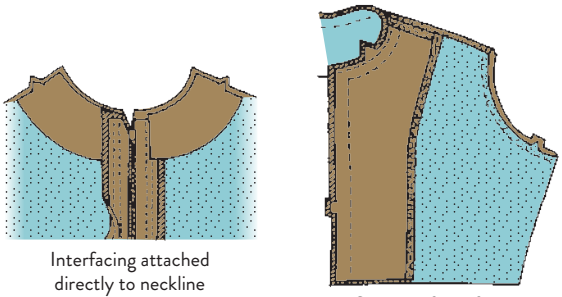


Tailor's tacking

9780170400336

Attaching interfacing

You may need to attach interfacing or stiffening to some sections of the clothing before joining. Interfacing can be either fused to the fabric using an iron, or stitched onto the fabric piece. The seam allowance of interfacing is usually trimmed to reduce the thickness of the seams.



Attaching interfacing to a garment

Sewing tools

A range of sewing machines are available for sewing fabric pieces and components together. For tacking, embroidering, beading and embellishing, there is a wide range of sewing needles for all sewing situations and weights of fabric.

Sewing machines and overlockers

The seams you use will be determined by the sewing machines that are available to you. You will probably have access to domestic sewing machines and overlockers; you may be able to use industrial machines.

- **Small domestic sewing machines** – these sew straight, zigzag and simple overlocked seams through light to medium-weight fabric. These machines usually allow you to adjust the length and width of stitches, and have a range of in-built stitches and automated buttonholes. Sewing speed is slow to moderate.
- **Domestic or compact overlockers** – three- or four-thread machines provide options for sewing a range of different overlocked seams. They have a small blade that cuts the fabric as the seam is sewn. Used for sewing light to reasonably heavyweight fabric.
- **Industrial sewing machines** – these machines are usually more solid and stable (and heavier), more consistent in their stitching, can sew through thicker and heavier fabrics and sew much more quickly. They should be used by experienced sewers only.
- **CAD-enabled sewing machines** – most new sewing machines have some form of computer technology to select stitches and drive the mechanism. However, some domestic and industrial sewing machines can be computer-driven to sew CAD embroidery designs. Domestic sewing machines usually have to be rethreaded for each new stitching colour.

Bernina, www.bernina.com.au

Bernina 720/embroidery machine

9780170400336

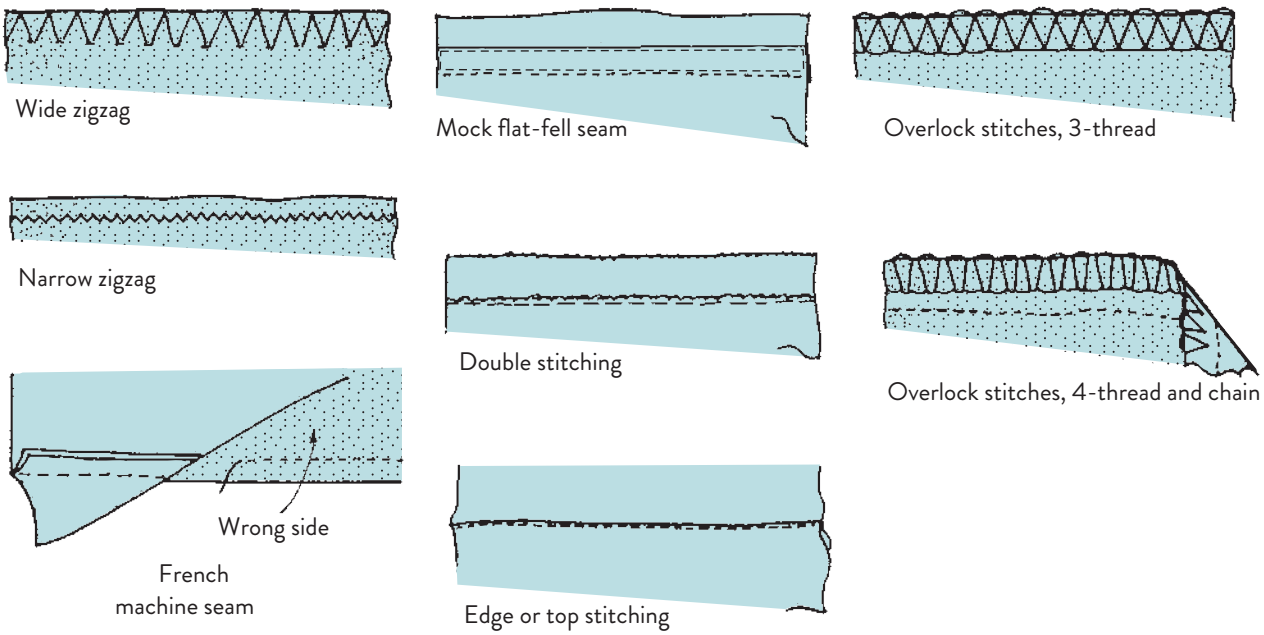
It is critical to thread sewing machines correctly – if this isn't done, the thread will bunch and knot and the sewing machine will jam, and if it is forced to run, parts may break. Make sure that you check the sewing machine manual for correct threading and bobbin placement and check that all needles are suited to the fabric and sharp if required.

Joining

The choice of seams will be determined by the weight of the fabric being joined and the position or function of the seam. A sheer fabric will need a seam that looks neat and prevents the edge from fraying – a French seam might be an appropriate choice. The crotch of a pair of trousers, on the other hand, needs to be very strong, so a reinforced seam would be suitable. Overlocked or zigzag seams are needed for stretch fabric, but can also be used in other circumstances.

Seams to use

Hand-sewn	• Tacking: long running stitch (for a temporary join) • Running and backstitch seams (for fine work, beading, embroidery in small amounts)
Machine-sewn	• Straight • Wide and narrow zigzag • Mock flat-felled seams (to reinforce and add a decorative topstitch) • Edge stitching or top sewing • Reinforced/double (for seams under pressure) • French (for sheers and mainly straight seams)
Overlocked	• 2-, 3- and 4-stitch seams (with chain) • Flatlock • Rolled hem or decorative edging
Fused	• Application of heat • Application of adhesives and heat/pressure

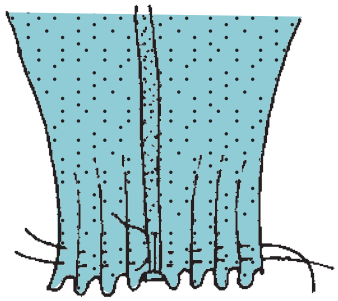


Some examples of seams

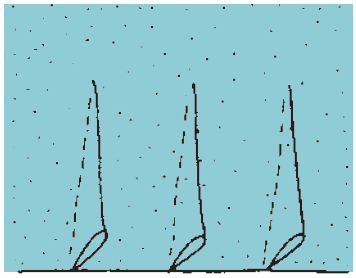
9780170400336

The following seams may need extra care during the joining process:

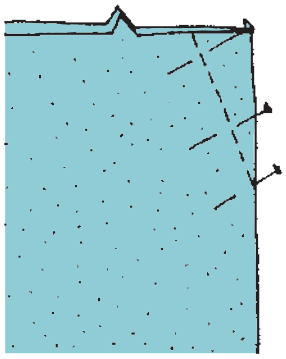
- gathering
- darts
- easing (attaching a curved piece to a straight piece, or attaching two differently curved pieces together)
- shaped pieces (e.g. curves onto straight edges, corners)
- pin tucking and pleating.



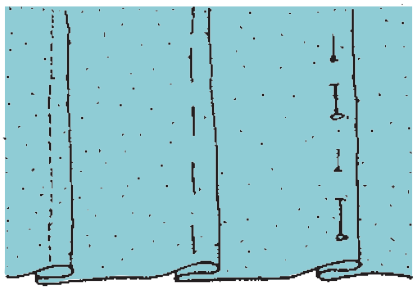
Gathering



Dart tuck



Single-pointed dart



Pin tuck

Some examples of darts and folding seams

Insertions and additions

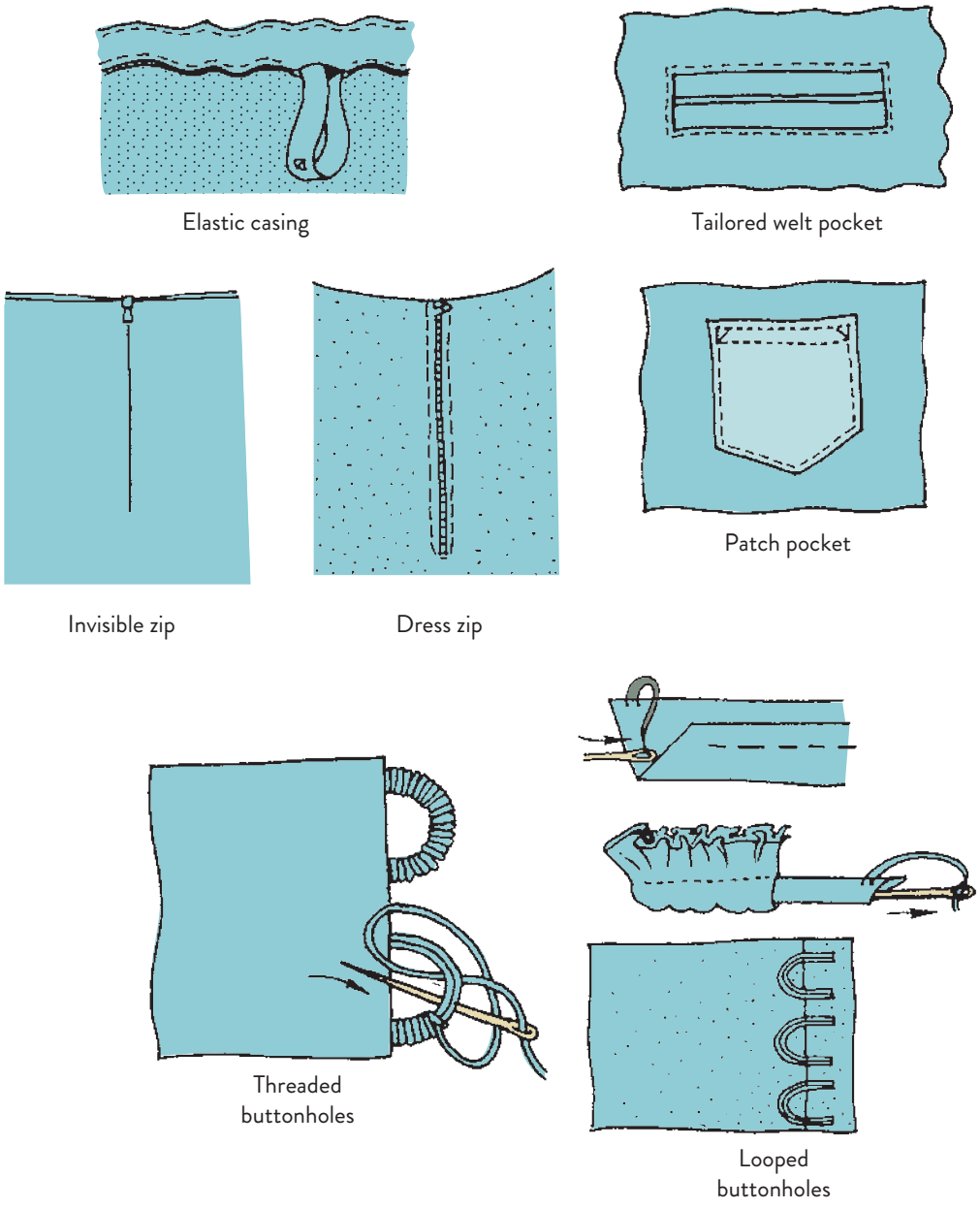
Many processes require the insertion or addition of extra fabric or other components for functional and decorative purposes, e.g.:

- zips
- pockets
- **plackets** and welts
- buttons and buttonholes
- boning
- loops (rouleaux or commercial loops)
- fasteners (snap fasteners, hooks and eyes, velcro, cord, toggles and buckles)
- lace
- elastic.

placket cloth that reinforces a split or opening

Some of these details can be quite complex, and can reveal the skill of the maker and the level of garment or product quality.

9780170400336



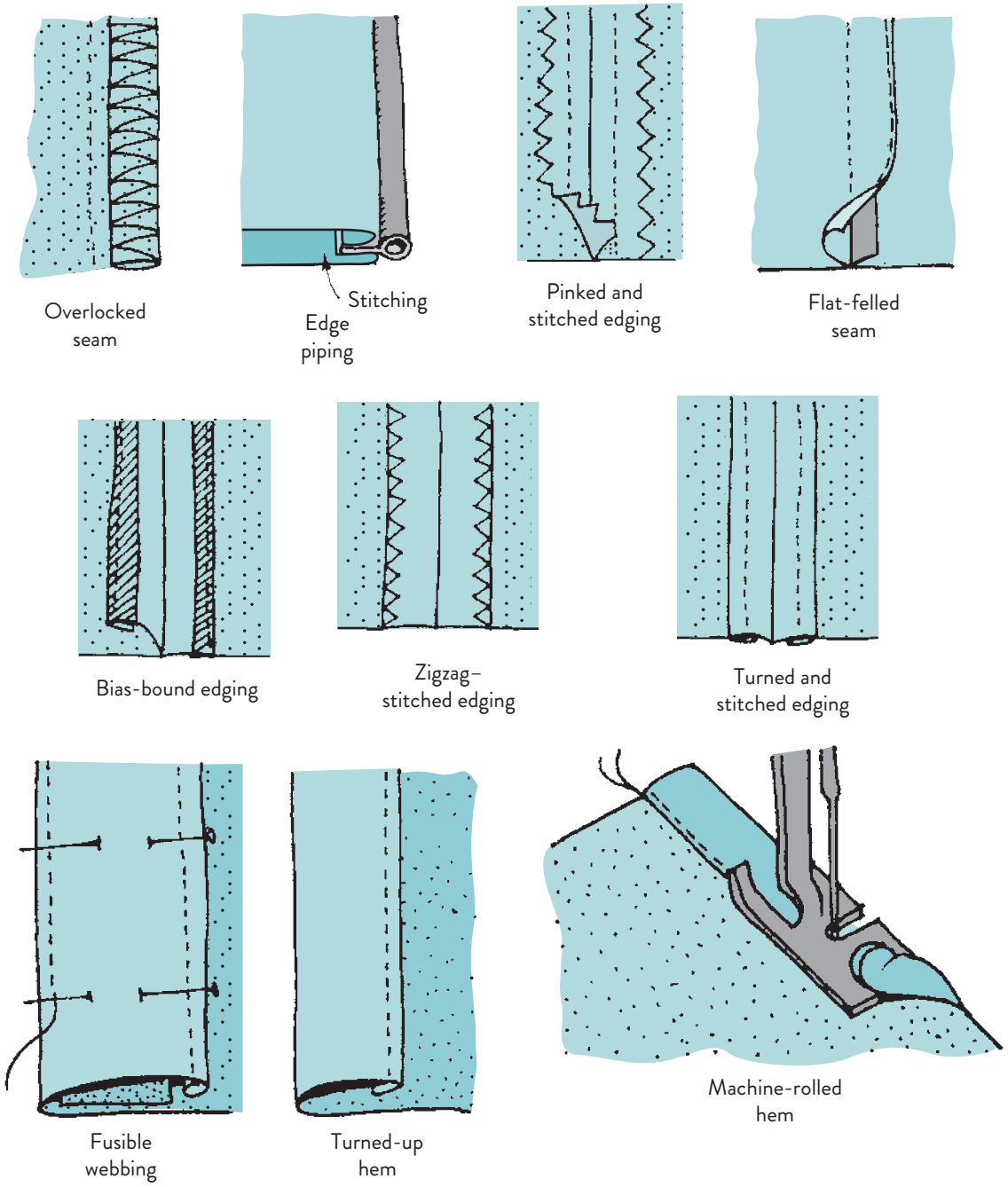
Some examples of insertions and additions

Finishing and edging

The fabric or situation determines the choice of forms of hems and finishing processes, such as:

- piping
- hand-sewn, fused or machine-sewn hem
- rolled hem
- topstitched hem
- bound edging
- zigzag-stitched edging
- flat-felled seam
- overlocked seam.

9780170400336



Examples of finishing stitching

Other forms of finishing include:

- waterproofing
- tape-sealing seams (used for wetsuits and waterproof jackets)
- starching
- laminating (applying a film of plastic to the surface).

9780170400336

Pressing and steaming tools

These tools are used to remove creases, to create a neat, folded edge in fabric, and to flatten seams after they are sewn:

- steam iron
- steam press
- steam wands.

Irons operate at high temperatures and tools that produce steam can cause severe burns. All of these ironing and pressing tools need to be used with caution.

Industrial processes and equipment

- CAD for sizing patterns and planning layout to reduce waste
- Motorised saws or CAD laser for cutting out
- Use of industrial sewing machines and steam presses for assembly and finishing
- Machine knitting
- CAD-driven embroidery machines
- Digital and multicolour roller printing processes
- Finishing processes – e.g. stone washing

Decorative processes

Decorations and embellishments are the details that can make a garment or product unique and individual. The application of decorative techniques may relate to the interests and tastes of the user, reveal the creativity of the designer/maker, or may tie the product into a particular era or style.

Decorative processes or techniques may be performed at different stages during construction. Some processes, such as printing and painting, are easier to do before the fabric is cut or joined. Other processes may be completed either after the pattern pieces are cut or after the garment or product is put together.

There are a number of very useful books and websites that provide detailed information explaining how to design with and carry out specific decorative processes. Make sure you investigate these during your research and design phases, as these processes allow you to explore creative possibilities and display high levels of skill.

Printing and painting

Printing on fabric allows a pattern or image to be applied to the fabric through paint or ink sitting on the fabric surface. Printing can be done in a number of ways:

Shutterstock.com/Georgiy Martynov

Silk-screen printing

- **screen printing** – a stencil is cut and attached to a mesh screen, or a photographic emulsion is applied to the screen, then exposed to light. Originally, screens were made from silk; they are now more commonly made from a synthetic mesh. The fabric to be printed is stretched over a printing table or pad, the screen is aligned on top, then fabric inks are forced through the screen with a squeegee. Silk-screen prints can be single-colour or multiple-coloured images – each colour needs a separate screen and print process.

- **block printing** – a block is created, usually carved in wood, and then paint is applied to the surface. Differently shaped blocks and different colours can also be used to create a printed pattern.
- **printing from nature** (eco-printing) – using leaves, flowers and found objects to dye natural fabrics. Fabrics are treated with a mordant (i.e. soaked in simply sourced chemicals), then leaves, flowers and found objects, such as rusty coins and washers, are placed on one side. The fabric is steamed and then allowed to cool, the plant material is removed and the pattern revealed.

Look at the work and writings of India Flint, an expert in this field, or use the information at the Threadborne tutorial. A link to the tutorial is provided at http://nelsonpdtvce.nelsonnet.com.au.

India Flint, Windfall leafprints on silk

Windfall leafprints on silk by India Flint

Getty Images/Bloomberg/Asad Zaidi

Industrial roller printing (one roller for each colour). This is the efi VutekTX3250r for superwide format printing.

- **roller printing** – a process most commonly used in industry to produce printed designs on fabric. Metal rollers are machined with a print pattern for a single colour, ink is applied on the roller, then rolled onto the fabric. The number of cylinders in a print run indicates the number of colours printed. This is an efficient method of producing long lengths and large amounts of printed fabric, but it is not suitable for small lengths of fabric because of the cost of preparing the printing cylinders. You can find clear videos of the process online.
- **digital printing** – in which an image is produced digitally and then printed directly onto fabric. Large printing machines are used in industry, and allow short print runs, depth of colour, wide range of image and pattern choice, and the ability to change designs easily (when compared with roller printing, which requires metal printing rollers to be machined for printing). In schools, digital designs can be printed onto fabric using a laser or inkjet printer and fabric transfer paper.
- **sublimation printing** (industrial process) – a detailed print is computer designed and printed onto transfer paper. Fabric is then laid on the paper and passed through heated rollers, which transfers the print from the paper to the fabric. This process is often used for sports team uniforms. Search for videos of this process on your internet browser.

EFI Vutek TX3250r, www.efi.com

Digital fabric printing

9780170400336

Dyeing

- Tie-dyeing – patterns are created when fabric is wrapped tightly with string and then dyed – the tight stringing stops the dye penetrating the fabric. The well-known tie-dyed pattern is a circular 'bulls eye' shape, but folding, tying or clamping the fabric in different ways can create other patterns. Colours and patterns can be dyed over each other, creating overlapping designs and mixed colour shades.
- Shibori – this is a traditional Japanese form of printing that is similar to tie-dyeing, but much more complex and sophisticated. Shibori fabric was usually coloured with indigo dye (dark blue), but sometimes madder red or purple root dye colours were used. Fabrics from natural fibres can be used for this process, most commonly cotton. Shibori patterns are created by binding fabric with string, twisting, folding and pleating, holding with pegs, stitching, binding around objects, etc. The fabric can also be wrapped around a pole, bound and then scrunched together to make pleats. Fabric, once manipulated, is soaked in a dye bath or dip dyed (only colouring part of the fabric).

iStockphoto.com/Marina Zakharova

Links to examples of patterns produced by different manipulation techniques can be found at http://nelsonpdtvce.nelsonnet.com.au.

- **Batik** (wax resist dyeing) – hot wax is applied to fabric to create a pattern or image and then the fabric is soaked in dye. The wax resists the dye, preventing it from colouring the fabric. Layers of colour can be built up by repeating this process, covering more fabric with wax before each dyeing. Batik is a traditional Indonesian form of fabric decoration, particularly from the island of Java, where people have developed specific tools for the application of the hot wax (canting). Forms of wax resist dyed fabric have also been found in other cultures.

batik
a method of decoration using wax resist and dye

Embroidery and beading

- **Hand embroidery** – many different forms of surface stitching patterns and techniques are used in embroidery. These stitches are usually created in a contrasting colour to the backing fabric, and can be made to form an abstract pattern or an image.
- **Machine embroidery** – this can be done on a small scale using a domestic sewing machine, either using a presser foot/automated stitches, or free form, using a special embroidery foot, an embroidery hoop and the feed teeth in dropped position. Different coloured threads can be used to create a decorative line design or filled-in blocks of colour. Some larger sewing machines are computer driven – the sewing machine creates a single or multicoloured image guided by CAD design. In industrial situations, specially designed embroidery machines are computer-programmed to embroider quickly and efficiently. The machines are pre-threaded with a wide range of colours to produce designs using satin stitch.

Shutterstock.com/Ksju

Industrial machine embroidery

- Free embroidery (wash away) – you can create small amounts of your own creative fabric by machine sewing over yarn, fabric pieces, ribbons, braids, etc., attaching them onto a stabilising film or mesh. When the network of sewing is completed, the mesh, which is water-soluble, is washed away, leaving just the sewn materials.
- Sequins, beads, ribbons, braids and lace – these can be added by hand to all of the embroidery forms above to add an accent or highlight, or they can be used to create a design by themselves. Sequins and beads attract attention because they are highly reflective.

Appliqué

This decorative process consists of attaching shaped pieces of fabric to a backing material with either hand stitches or machine sewing (often using a satin stitch). There are a number of traditional forms of appliqué from different cultures that can be researched and applied, as well as modern forms. Some forms cut away the surface material to reveal a different fabric below. The appliquéd shapes can form an abstract pattern, or can create an image or picture. In some instances, shapes of the same colour are attached to provide a subtle textured pattern.

Quilting and patchwork

Quilting is a traditional form of fabric construction and decoration that can also be used in contemporary ways. Patchwork is created by joining different coloured and patterned fabric together to make an abstract design (often done in blocks, joined together). Quilting involves the application of running stitches through multiple layers of fabric to form a subtle decorative pattern.

Dagmar Binder

Handmade, seamless 3D felt by Dagmar Binder. Here, the artist has 'painted' directly with the wool fibres. Different coloured wool fibres are laid out and form a subtle blend with a watercolour effect.

Piped, fringed, ruffled or scalloped edges

Fabric can be folded and manipulated to create decorative features.

Felting

Felting can be used to make decorative patterns with different coloured fleeces matted together. These decorative fabrics can be used as a basis for further stitching and beading. Fine layers of felting can be applied over gauze-like fabrics to create lightweight, transparent, decorative felt. Felt objects can also be formed with needle felting techniques. To find out more, refer to the many books, resources and online tutorials on felt-making that are available.

Frou Frou Felt handmade bag with birds by Karen Hughes

9780170400336

CASE STUDIES FOR NON-RESISTANT MATERIALS

CASE STUDY

Bodypeace: bamboo clothing

BACKGROUND

After 15 years of working in retail in seven different shops, Anna Walsh conceived Bodypeace, motivated by a love of customers and wanting to do something good for the planet. She grew up in northern New South Wales and attended Nimbin Community School. Growing up and living in this area of Australia gave her a lot of exposure to spiritual and philosophical ideas, along with awareness of environmental issues.

Anna does not have a formal design qualification, but her extensive retail experience has given her a clear understanding of what customers want. Retail experience also provided her with a fortuitous contact: a Chinese factory manager with her own clothing label. The factory manager was able to assist Anna in getting started by teaching her the ropes and providing her with a vast amount of knowledge and contacts.

To establish her label, Anna started by borrowing on her credit card and working from home. Eventually she was able to move into external premises, enabling her to separate her work and home life. The premises gave her space to store stock and sell 'seconds' or old styles, interact with customers and run the office. This is quite different from larger clothing companies, such as Bonds, that keep all stock offshore. This is called indenting, and means that shops need to predict what will sell and order stock three to six months ahead of time.

Anna's business took off through word of mouth, including attending fashion trade shows. While these shows cost around $3000–$6000, they were good for publicity, helpful in creating contacts and usually resulted in customers (from retail stores) making wholesale orders with her. Business grew and six years later Anna was running four Bodypeace shops in the area around southern Queensland and northern New South Wales. The type of products and the ranges and sizes available has also grown.

Anna Walsh, wearing a Bodypeace garment

SATISFYING THE MARKET

In the first years, Anna's product was classical pieces for larger-sized women, made with bamboo fibre. Anna knew women's bodies and what they wanted. Bamboo is extremely suitable for these garments as it is soft and flowing and is considered to be a fibre that is sustainable. Her designs were fed by years of hearing customer requests and listening to their feedback:

9780170400336

'Mostly I made for mature women (40+), my designs were with those bodies (loose on tummy and upper arms!) and minds (no hassle, elegant, classic, dress up or down, works in summer or winter and NO ironing, throw in washing machine/dryer ... works anywhere in the world!).'

Now, not only many women but also men and teenagers are extremely grateful for her products. Over the years she has added a men's range, uniforms, jeans and socks for teenagers and more products for women of all sizes. All of this has come from customer feedback and requests. In 2015 a new winter range of unisex tracksuits was very popular and was expanded into unisex dressing gowns, skivvies and zip-up vests.

However, at this stage, Anna feels the need to cut back. She wants to cull the sizes and the ranges. Several years ago she started making her own sheets and towels. Bamboo lends itself nicely to sheets as it is 'thermo-regulating', suitable for all temperatures, and to towels as it is super absorbent. But she found that the bamboo sheets were not so profitable in small **production runs** and particularly when the Australian dollar devalued against the $US. If she went for larger runs then there was the issue of where to store all the stock. It is far more streamlined to stock bed linen from companies that specialise, then a variety of colours and sizes can be offered. It's the same issue with the socks, which she now also stocks from other 'bamboo' brands.

production run
a number of product units produced at once in a factory

She also had the chance to increase her business after entering *Shark Tank* on Channel Ten. *Shark Tank* is a reality TV program in which entrepreneurial contestants give their pitch to 'investors'. Two of the judges were keen to invest in her company for a share of profits. Anna chose to turn down their offer. She realised that she was ready to simplify things, spend less time on the computer and get back to being creative.

Bodypeace, www.bodypeacebamboo.com

Bodypeace men's T-shirt and women's jeans made from bamboo

CREATING THE GARMENTS

Anna communicates her design ideas to the factory manager, who gets the samples made up, and sends them over to Australia. Anna checks them and makes any necessary adjustments, and then the production run starts. Since establishing her label, Anna has visited China to check out the factory making her garments. It's a small factory with around 10 workers. She was happy to find that it wasn't an unkind 'sweatshop', and that it looked after its workers.

Finished garment lots or batches are sent to Anna, items are displayed in her shops and pre-ordered items are dispatched to various stockists around the country. She also sells her products online.

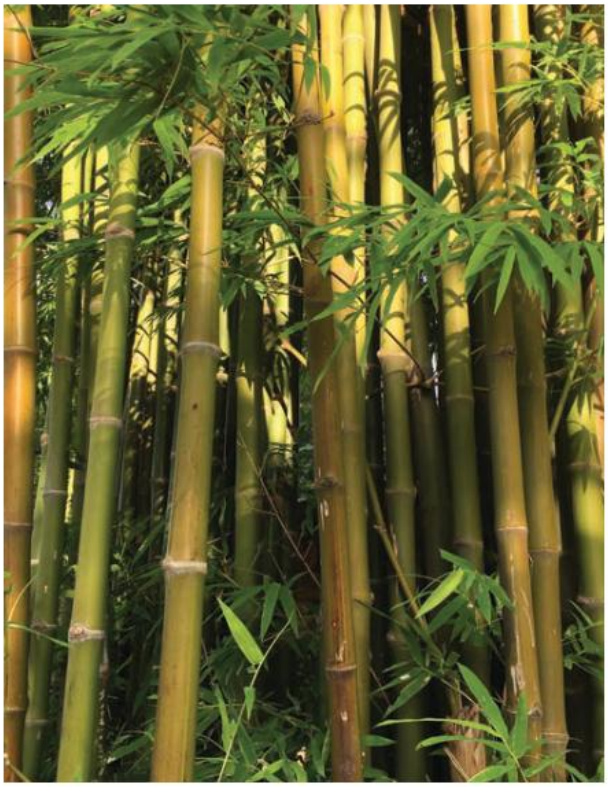
CHECKING THE QUALITY

In the beginning Anna had to vigilantly check all garments on arrival even though they had been checked at the factory. One lot that almost escaped her eyes had small holes that had been repaired by hand, like little darned patches. The lot had to be returned. Due to the relatively small quantities made, it was rare that there were many quality problems. Now that the business has grown she has employed a pattern maker, who creates specification sheets, and quality checkers in China, who look at the sheets and check widths in a design, quality of seams, etc. They won't settle for less, they also communicate with her and if it happens to be a minor flaw then there is room to negotiate the prices.

9780170400336

SOURCING THE BAMBOO FABRIC

Bamboo fabric is very expensive and is in short supply, as there is currently a huge demand for it worldwide. Anna requires bamboo fabric of a high quality. Due to the high costs, Anna considered processing the fibre herself, by boiling down her own bamboo. Even though that experiment didn't turn out to be a viable alternative, she learned a lot about the fibre. Fabric that is 100 per cent bamboo loses its shape, and bamboo mixed with cotton tends to pill. The fabric Anna uses is woven to her unique specifications in terms of its weight (it is heavier than most weaves, which means it hangs well, looks elegant and doesn't need ironing); is coloured with organic dye; and is mixed with 8 per cent elastane so that it holds its shape. It's also important that the fabric fits in with Anna's sustainability criteria. Fabric of this standard requires a minimum order of $20 000, and close to $6000 per colour.



Shutterstock.com/Angrybirds

Bamboo stalks

Anna has spent a lot of time researching to find a cheaper source, but each sample that she is sent is either not heavy enough, or not available in her preferred colours, or the company expects big orders in one particular colour. At one stage she changed to a bigger, more experienced and cheaper fabric manufacturer; but the fabric was never quite right. It felt rougher and stiffer. She discovered that placing it in a dryer softened the fabric to her expectations. After many product returns from wholesalers, she found herself investing in several clothes dryers to 'tumble' all her product. Not only was this a nightmare experience, it also darkened the reputation of her product. After a lot of dissatisfaction, stress and expense, she returned to her original factory.

Part of simplifying the business is to now make all her Bodypeace clothing from the same fabric; the same weight and blend of colours. This means bigger fabric orders; all clothes can be cut from the same rolls of fabric; and it is a far more economic way of operating.

PRODUCT VERSUS PROFIT

Anna is like many creative people with a vision – while she is good at designing and selling, she has learnt to contract out the business aspects that aren't her cup of tea. Wherever possible, she used government schemes such as Jobstart to assist her in hiring people.

Fabric is paid for by weight, and one of Anna's assistants proved her worth by calculating how much weight was in each garment, how much it cost to make each item, the retail price and the resulting profit. In the early days, she used these calculations to make decisions about which products to exclude. One of them was a singlet, as customers baulked at the price. However, in recent years her customers understand, want and are prepared to pay for the quality of Bodypeace products.

You can find more details about Bodypeace and the benefits of bamboo at the company's website. A link has been provided at http://nelsonpdtvce.nelsonnet.com.au.

Jacinta O'Leary spoke to Anna Walsh at her retail shop/office at the industrial estate in Byron Bay, New South Wales, in January 2017.

CASE STUDY

Emily Barrell: master embroiderer

Emily Barrell studied textile design at Central Saint Martins College in London. She is a creative embroiderer, based in Paris, producing exquisite embroidery samples for the prestigious French fashion houses.

Emily worked for years at the House of Lesage, the oldest embroidery atelier in Paris. It was here that she advanced her skills in embroidery: 'I just made stitches up as I went along. I had no idea how technically based embroidery is; there are so many specific stitches and techniques, and it takes years of practice to be precise, and quick, at all of them.'

While not as technically advanced as some of the artisans there, who had a lifetime of experience, she was the 'creative collaborator' between the designer and the embroidery experts – her role being to design the pieces.

Neck piece designed by Emily for the Chanel Winter 2014 range

A sample of Emily's embroidery design for the Chanel Spring 2015 range, based on the paintings of Emile Nolde

In 2002, Karl Lagerfeld (for Chanel) purchased Lesage and five other specialist couture ateliers to ensure their survival. He launched an annual Metiers d'Art catwalk show, to celebrate and showcase the culture, philosophy and work of their artisans. They included: millinery, shoemaking, button and costume jewellery, gold and silversmithing, and feather and flower decorative work. People who work in these ateliers are experts with rare and refined skills.

Six days before one of the Metiers d'Art shows Emily was stitching black and gold sequins onto a drawing of the Chanel logo. The design may have been used to adorn accessories but Lagerfeld was still undecided whether or not it would work: 'He works a lot on impulse. He may decide he would like 10 of them the day before the show.' Or it may simply end up being added to the extensive archive at Lesage, an archive dating back to Napoleon III.

Some of Karl Lagerfeld's ideas have come from this archive; and he may decide only a month before a show how the embroidery is to be included in a garment. One sample was the size of an A5 piece of paper and took 50 hours to complete. Karl's drawing showed the embroidery covering two whole outfits.

Emily spent 13 hours simplifying the sample into a lighter but still exquisite version. It required six

9780170400336

seamstresses to adorn the outfits. She saw her role as finding new techniques, not just 'robbing' the archive.

In 2014 Emily started her own business creating design embroidery for fashion houses. Her highly valued work, her experience and reputation have allowed her this independence. With her vast repertoire of work (and influence from the Lesage archives), she brings creativity and innovative techniques into the new fabrics that will make up the garments for the next season catwalks.

A finished piece of embroidery is the product of a partnership between the designer and the artisan. It is all one-off, custom work, commissioned specially. The designer starts with a theme, and Emily responds with design samples. Each design takes hours of handwork and may or may not be used. It requires the most delicate, exquisite and difficult sewing. There could be many different elements in one design: cotton, gold cotton, red thread, brown thread, silk threads, gold leather, gold pearls, beads or sequins, ribbons or braid.

Once the design has been created and transferred onto a grid with a key, samples are made. The cloth is held in a wooden frame, patterns are close by, lace or tulle is stretched across, beads ready. Each frame has a piece of tracing paper, studded with holes, through which the embroidery patterns are transferred to the fabric using a fine powder in a technique called 'pouncing' – very similar, in fact, to the technique used to transfer images onto plaster in fresco painting. Each piece is embroidered, according to the key prepared by a sketcher (each time a couture dress is made the embroidery is reconfigured to fit the measurements of the customer) and then sent back to the fashion house to be constructed into the final garment.

Hand embroidery is at times a difficult task, it strains the eyes, neck and shoulders. It is intricate and delicate work. When preparing for a fashion show it may require long days, working till the wee hours of the morning for weeks on end. It's not for everyone; it has to come from the soul.

Jacinta O'Leary spoke to Emily Barrell in January 2017.

A fully embroidered Chanel piece for the Winter 2014 range, based on the theme of concrete – embroidery design by Emily Barrell

Courtesy Emily Barrell

9780170400336

CASE STUDY

FOOL clothing

ABOUT

Rowena Doolan is the owner and designer of FOOL clothing and has been based in Prahran, Melbourne, for over 20 years. The name of the label FOOL reflects her philosophy that we should all wear a bit more colour, be a bit more adventurous. She likes a melange or 'mish-mash' of colours in her own outfits and likes to create this for her customers.

Fool Clothing

Rowena Doolan in her shop

INSPIRATION

'There is so much doom and gloom around – I want to transport people to another place. I'm inspired by colours, textures, shapes and patterns that are bright, bold and irreverent.

'When I finished my studies in fashion design I spent a lot of time living and working in India. The colour in India is incredible – that place just vibes with colour! Colour makes me feel excited; it gets my brain moving. Colour is one of my biggest inspirations. So is the figure of the Fool, which is the name of my label. Fools are ludicrous, they play, they make people laugh. They are very serious about having fun and I love that idea.'

She is also inspired by the way fashion can draw out people's own creativity, and says, 'My customers inspire me. It's incredible to see garments worn and paired in ways I hadn't imagined.'

DRAWING AND DESIGNING

Rowena draws up ideas with coloured pens, including hairstyles, shoes and makeup. The complete look is important for creating and designing the garments.

'I'm always designing. Each season reflects my mood, my interests. I also draw on the whole world of design that is around me, in Australia and globally. Part of my process is to gather images, swatches, patterns, fabrics and garment shapes. I make inspiration boards from this stimulus. My designs grow from there.'

All garments require patterns. Some of the simpler patterns she makes herself, but a pattern maker does the more complicated ones. It's such a time-consuming job, and her time is better used producing new designs, sourcing fabrics and organising creative collaborations with other local makers.

KNITWEAR

'Knitwear is something I love to design. I use pure wool and cotton yarns for my winter and summer knits, respectively. I love selecting gorgeous colours, creating **intarsia**, jacquard patterns and different textures and using them in interesting ways.'

intarsia
a method to incorporate coloured shapes and patterns in knitting

Ideas for knitwear are drawn up and handed to a knitwear pattern maker to digitise, which Rowena oversees for fine tuning. The fabric has to be knitted to the specifications of the garment design and pattern size. Once that is done they are cut and sewn. The neck ribs are linked on with a **linking machine**.

linking machine
a machine that matches up and stitches knitted seams

Fool Clothing

A multicoloured chunky knit

9780170400336

Over the years, the knits have ranged from being made with very thick yarn to finer yarn, but it's colour, always colour, that Rowena's clothes are known for. Many of the woollen winter jumpers have close to ten colours or ten shades of one colour. Many of the knit patterns are intricate.

Fool Clothing

Textured knits in shades of blue

MAKING THE CLOTHES

The patterns are sent with the fabric to the maker, who cuts and sews them. All the manufacturing is completed in Melbourne. This is unusual when most clothing factories in Australia are closing down. However, it gives her more (and close) control.

'Because all of my garments are made locally, I'm often busy visiting my makers. I coordinate and oversee all the production in each of the factories. It's so important for me to have close relationships with them. I love creative collaborations and it's also important to support local industries.'

RETAIL

'It's important for me to push the boundaries of streetwear, but I also need to run a sustainable business. I need to have reliable sellers in store; it allows me to really experiment with new season ideas. My core garments that people love are a playful range of oversized dresses, printed scarves, wide-leg pants, pea coats, biker jackets, pinafores, boat neck print tops and basic T-shirts. We repeat these shapes in different fabrics each season. They are good pieces because they complement or clash with our new season stories. Being able to pair new season garments with older pieces is really important for me. I use excellent fabrics in my garments and so they last a long time.'

Customers not only love the quality, the colour and the eye-catching items, but they know they are getting a product that is close to unique and that they are proud to be seen in. You can read about and see more FOOL clothing at their website. A link has been provided at http://nelsonpdtvce.nelsonnet.com.au.

Jacinta O'Leary spoke to Rowena Doolan in January 2017.

9780170400336

Shutterstock.com/Rawpixel.com

SECTION 3

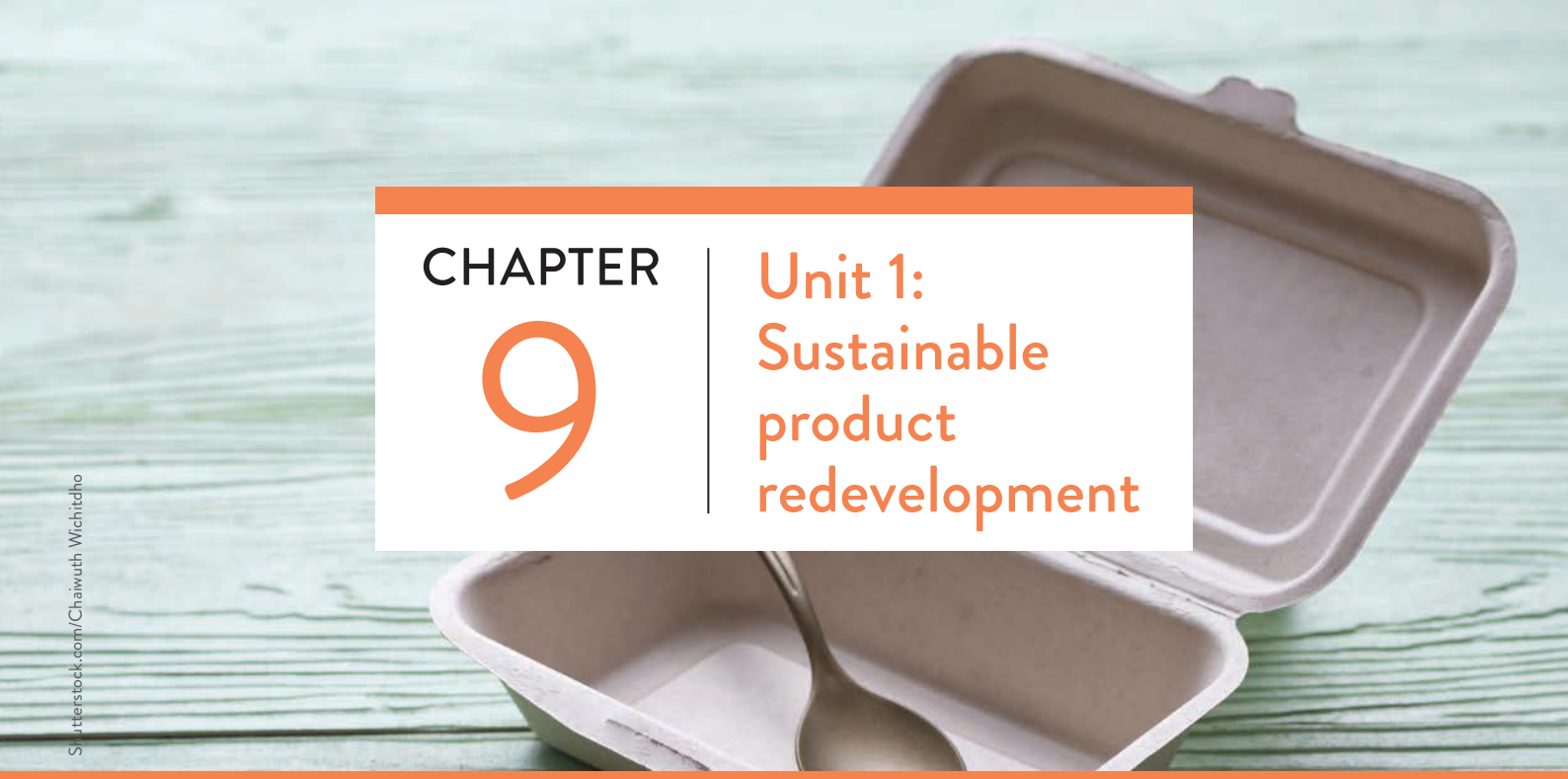
UNITS 1 AND 2

Chapter 9: Unit 1: Sustainable product redevelopment 246

Chapter 10: Unit 2: Collaborative design 268

Chapter 11: Design inspiration 291

9780170400336



Shutterstock.com/Chaiwuth Wichitdho

CHAPTER 9 Unit 1: Sustainable product redevelopment

CHAPTER FOCUS

In this chapter you will learn about:

- The product design process p. 247
- The product design factors p. 247
  - intellectual property – attributing work to the creator p. 247
  - sustainability p. 249
- Analysing a product to redevelop p. 250
- Unsustainable products p. 252
- Redeveloping a product – including writing the design brief and evaluation criteria, research, design and development, planning and production p. 254
- Planning and production – including knowledge of materials p. 259
- Evaluation p. 263

CONTENT OF UNIT 1

In Unit 1, you will redevelop an existing commercial product to improve its purpose/function and its sustainability. To do this you will follow the product design process. Along the way you will be informed by the product design factors. They will be the basis for analysing the product you choose to redevelop and for writing your design brief.

Before you get started, it's wise to learn about and become familiar with:

- the product design process
- the product design factors, with a focus on:
  - intellectual property (from the Legal Responsibilities factor)
  - the purpose, function and context factor
  - design elements and principles (from the visual, tactile and aesthetics factor)
  - sustainability frameworks such as life cycle assessment (LCA).

To revise the product design process, go to Chapter 2. An example of how the product design factors apply to a product and can be used as a basis for analysis can be seen on pages 14–16 and page 248.

9780170400336

THE PRODUCT DESIGN PROCESS

The product design process is central to all the units in this study. In each unit you are expected to demonstrate how you followed it.

The product design process in VCE has been defined in a particular way that is suited to the classroom and student work. It is not necessarily the exact process that a designer works through for every product. This is because there are so many different design problems and design situations, and so many different solutions to any given problem. They vary tremendously – according to the complexity or simplicity of the design situation or problem, the product, the end-user or the size of the company and its market reach.

You may find that you use the product design process differently in each VCE unit, e.g. one project you are working on may require a lot of research to get started; another may require a lot of designing; one may need more tests or trials, while another may require more research once the design has been finalised.

Unit 1 requires you to redevelop an existing product to improve its purpose/function and its sustainability. This includes an analysis of the product – both as a starting point and as a comparison at the end.

THE PRODUCT DESIGN FACTORS

There are many factors that influence all the activities that designers carry out when working through the product design process. You only need to think about a bag in all its versions and specific uses to imagine some of the influencing factors on its design. In this study they are called the **product design factors**.

Each factor has many parameters. One of the parameters of legal responsibilities is intellectual property, which you will start with. The other factors are covered in detail in Chapter 4 and in a product analysis in the next heading.

Intellectual property (IP)

The principle of intellectual property (IP), its implications related to product design and the importance of attributing the IP rights of the original designer is to be carried through all units. *Read the section in Chapter 4, pages 108–112, about intellectual property (especially copyright and moral rights).*

In Unit 1, you will be starting with a commercial product to redevelop (using another's ideas for inspiration), therefore you need to attribute the IP of the product's creator.

Note that quoting source websites such as Google Images, Pinterest, Flickr, personal blogs and other social media or 'photo-sharing' websites is not the same as attributing the creator or acknowledging IP. These sites do not always include the creator's name, nor are they the true source of an image; i.e. they are not owned by the photographer or the publisher where the product originated. They are like libraries or bookshelves and their purpose is to collect and manage images. You need to dig deeper and do some more searching to find the person who created the product, the true IP owner.

As it is often difficult to find the name of the creator of a product when searching the web, it is a better idea to research a design style you like, find out the name of its prominent designers and then search for their work. You may even choose a product from a case study on sustainable practices, or a product made by a designer in a period or style described in Chapter 11. An even better idea is to obtain an actual product that you can try out to assess its functionality and/or quality and to feel the materials.

Once you have decided on a product and found the name of the creator, you need to analyse the product. You can do this using the product design factors.

9780170400336

Analysis with the factors

To revise each of the nine product design factors, go to Chapter 4. When applying the product design factors to the analysis or design of any product, you will see from the brief discussion below how they overlap and interconnect to impact and influence a designer's choices depending on the design situation.

Applying product design factors

The following discussions use the example of **a bag** to consider how the product design factors are used in analysis and design.

Purpose, function and context

For this factor, you need to consider what it is used for – what its 'job' is, how it will be used, by whom and where. For example, the primary purpose or function of any bag is to hold and carry things. But every bag has a more specific purpose, and this impacts on:

- the size it will be
- the functionality it will require
- the organisation of its sections and/or pockets
- the weight it will be when it is full
- how it will keep its contents secure
- its quality (fit for purpose) and reliability
- how safe it will be for the user (sharp edges that scratch or cut, neck or back strain if heavy, etc.)
- how it will be carried.

All of the above dot points can be taken care of by secondary functions that support the primary function. They will all contribute to its **performance**.

performance what something needs to do to fulfil its purpose or primary function

Consider the context: Who will be using it, where will they be using it and what will they be using it for? *To revise purpose, function and context, go to page 92.*

User-centred design

User-centred design focuses on the user's needs. It involves consideration of how a product will cater for the specific needs of the user, which means that it overlaps with many of the factors related to function and context, such as ergonomic data, safety, performance and quality. Consider how well the bag is designed to cater for the people who might use it in a specific way, in specific situations. Does the bag need to confer status to the user? Is it a fashion item or purely functional? Does it need to cater for a physical impairment of the user? *To revise user-centred design, go to page 96.*

Innovation and creativity

Innovation includes any novel (new) features that a product might include in its functional design, aesthetic design, its approach to sustainability, such as the use of new or used materials, or even in the way it is sold and marketed to its target market. Does the bag have innovative features?

Creativity is about interesting combinations. Has the bag been designed creatively? *To revise innovation and creativity, go to page 102.*

Visual, aesthetic and tactile factors

Visual, aesthetic and tactile factors are how the decisions on colours, shapes, lines and textures will be used and how they will be arranged, i.e. in what proportions. When analysing a product, consider how the designer has used the design elements and principles to create the look, feel and style of the product. Have they used these effectively? Does the bag need to feel good, look fashionable or have an understated **utilitarian** look? *To revise the design elements and principles, go to Chapter 3.*

utilitarian focusing on what is useful

www.globalexchange.org

Shutterstock.com/Sebastian Crocker

The product design factors, such as sustainability, are addressed differently depending on the context: at left, Global Exchange Fair Trade bag made from recycled truck tyres and at right, a shopping bag made from hessian

Sustainability

Sustainability is increasingly important to consumers when purchasing products, and 21st-century designers are urged to consider it in their design. Consumers want to know about the supply chain, and will be looking to see:

- what the bag is made from (its materials and how sustainable they are, where and how they are sourced, extracted, processed, transported, etc.)
- how it is made (whether its processing creates toxic waste or has high energy requirements; whether the workplace is safe and workers have reasonable conditions)
- the quality of construction and whether it will be a longer-lasting product.

This factor can overlap with user-centred design. Having an understanding of or concern for where the bag and its materials come from can create an emotional connection – a feeling of satisfaction that it was chosen thoughtfully, and therefore will be cherished and looked after.

To revise sustainability, go to Chapter 5. You will find discussion of the supply chain on page 128. To revise sustainability issues for different materials, go to pages 164–5 (wood), 183–4 (metal) 197–8 (plastic) and 222–3 (textiles).

Economics: time and cost

The retail price and affordability of the bag also relates back to user-centred design factors: is it value for money for the customer?

Time also relates to economics: if a product is too slow in getting to retail, it may miss its market – i.e. it may be out of 'fashion'. Wasted time is costly for manufacturers. *Refer to page 129 for information related to economics.*

Legal responsibilities

The legal responsibilities that could relate to a bag include:

- intellectual property (IP) – the bag designer cannot just copy other people's designs or this will be considered an IP infringement; if the bag design is original, the designer has to decide whether to register the design, which costs money.
- the occupational health and safety (OH&S) of the workers in the company
- any Australian or International Standards that might exist for materials for a bag and the manner in which they are processed, e.g. tanning of leather
- that the bag must be a safe product to be sold in Australia.

Go to pages 108–13 to revise legal responsibilities.

9780170400336

Materials and technologies

When analysing, consider how appropriately a designer has used materials, and how effectively they have used technologies (equipment and processes) to make the product. The available materials and technologies relate back to other product design factors, such as: economics – cost and time; visual, tactile and aesthetic; sustainability.

Examples of overlap:

- How expensive is the material to source?
- How accurately and how quickly can the bag be made?
- How beautifully can the bag be constructed?
- Is it a high-quality bag, made to last?
- Is it made from materials that are a good sustainable choice?
- Can the materials be easily recycled or reused after the bag is disposed of?
- What are the most suitable materials for its specific purpose?

To revise materials, go to Chapters 6, 7 and 8. To revise the technologies factor, go to page 116.

ANALYSING A PRODUCT TO REDEVELOP

Here are some suggestions for analysing your product similar to the discussion of how the product design factors are considered in a bag.

You will examine:

- who created it (IP)
- its primary function (what does it do and how does it work?) and supporting secondary functions
- how it currently fulfils the need of a user (this is a reference to user-centred design factors)
- how it appeals visually to the user
- how sustainable it is.

To present your analysis, take an image or photo of the product and paste it into a page so that you can annotate it. It may be necessary to have several copies of the image to allow for clarity and room for your annotations. Some suggestions for your analysis and annotations on each copy follow.

1 What is the product, who is it for and what does it do?

On the first image of the product:

- Identify the product clearly by including its name, brand or company, and the name of the person who designed or created it. If you cannot find the creator's name and it is an image you have sourced from the Internet, include the URL (but not image collecting sites such as Pinterest; *see information on intellectual property on pages 108–12*).
- State clearly its primary function. What context would it be used in (who, what for, where and why)?

9780170400336

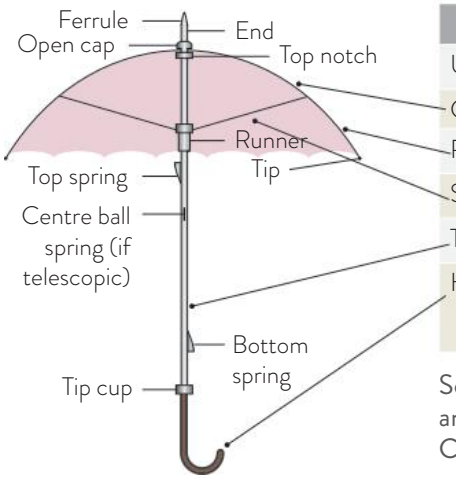
- Who is the typical user of this product? How does the product suit them?
- Annotate the secondary functions (the functional aspects that support the primary function) and explain them briefly.

Go to pages 92–3 for information on primary and secondary functions.

iStockphoto.com/diane39

Shutterstock.com/Romariolen

Who do you think is the user of each of these umbrellas, and in what situations?



Description	Function	Primary	Secondary
Umbrella	To protect from rain	X	
Canopy	To repel rain and sun	X	
Rib	To stretch canopy		X
Stretcher	To push ribs out to stretch canopy		X
Tube	To support canopy section		X
Handle	For user to hold		X
	To hook onto something for storage		X

Some suggestions for annotating an umbrella to indicate the primary function and some of the secondary functions, also labelled and explained in the table. Can you explain more of them?

2 How does it appeal to the senses?

On the second image of the product:

- Look at how the product appeals visually (its aesthetics) and tactilely (to touch).
- Annotate and describe the design principles and elements that are evident. Think about how they appeal to the user.

Go to pages 81–9 for information on design elements and principles.

3 How sustainable is it?

On the third image:

- Find out the materials used and explain their suitability according to their characteristics and properties.
- Research the materials and include information about their sustainability (e.g. source of raw materials, can they be recycled?).
- Comment on quality, durability, or the method of construction or finish.
- Comment on cost, and whether you think it is a product of value.

9780170400336

More on analysing the sustainability of the existing product

Although you will learn several models for sustainability, you can start with Life Cycle Analysis/Assessment (LCA) and life cycle thinking in Unit 1. This focuses on the whole life of a product, from the sourcing and extracting of the raw materials to the disposal methods at the end of its life. *Revise LCA on pages 123–4 in Chapter 5.*

Research the life cycle impacts of the product by finding out as much as you can for the product and similar products. Things to consider in your research:

- Are the materials identifiable? From which country do the raw materials come? How were the raw materials sourced or extracted?
- Can you think of anything in the product's design that could have reduced its impact at processing of the materials and manufacturing of the product?
- How far has the product travelled to be purchased? Could it have been made lighter for transport or 'flat-packed' to avoid bulky packaging?
- Are the materials recyclable/reusable or not? Can they be detached quickly? What are the components made of and could they be reused? Are the parts that often need replacing easily detachable? Can the components be reassembled without damage?
- What is the lifetime of the product in terms of aesthetics, reliability and durability, maintenance and repair, product-user relation?
- How do you think this product would be disposed of? Reused (or components reused)? Remanufactured or refurbished? Recycled? Incinerated? Sent to landfill?

You can also consider the interaction and connection between the three pillars of sustainability: social, economic and environmental systems. How does the product deal with these?

The LCA calculator website requires a subscription but has a useful LCA calculator. Go to WiKID, the Industrial Design Engineering Wiki, and go to 'Delft Design Guide', click 'EcoDesign checklist' and scroll down to click 'Example of an EcoDesign checklist'. You could also use the EcoDesign Quick Guides (developed by Design Victoria) now available on the DATTA Vic website. Links to these websites are at http://nelsonpdtvce.nelsonnet.com.au.

For the other models – Cradle to Cradle concept; design for disassembly (DfD); extended producer responsibility (EPR) or product stewardship – see page 359.

UNSUSTAINABLE PRODUCTS

In Unit 1, you are expected to understand the impact of unsustainable products. In a nutshell, the impacts could be defined as:

- an increase in waste and its implications for landfill, and the pollution of air, soil and water
- increased use of resources, particularly those deemed finite (non-renewable)
- damage to environmental, social and economic systems.

To revise sustainable practices, re-read the brief explanation on pages 104–7 and the more detailed explanations and case studies in Chapter 5. All products use resources, but many decisions can be made in their creation to lessen the negative impacts.

Sustainable practices

Unit 1 requires you to examine claims of sustainable practices by designers. Many sectors in our community are strongly urged to think sustainably, and design is no exception. In fact, more companies are using designers to help them respond to these 21st-century needs. Designers may not only be responsible for creating better products, they may also help create better systems and methods within a business. Unfortunately, **greenwashing** also exists. *To revise greenwashing, go to page 127.*

greenwashing giving the impression that a product is 'green' when it is not; misleading labelling or accreditation

As a student of Product Design and Technology and a possible future designer, it's important that you learn to discern between greenwashing and credible statements. *Refer to the case studies on sustainable design in Chapter 5 and at the end of this chapter.*

Some questions to ask in your case study are:

- From where are the materials sourced – e.g. from forests, mines, petroleum, plants or animals, and from what country?
- How are the materials processed into a useable form?
- Does extracting the materials involve dangerous practices that cause harm to people?
- How are the products manufactured?
- Does the product's use impact on either the environment or people, and does it cost the user money to use?
- What are the benefits of the products in terms of 'people, product and planet' (or any other sustainability model)? That is, how do the products benefit or harm society (manufacturers, users, workers, community, etc.)?
- Can the product be used and cared for in a way to extend its life, and are these instructions communicated to the user/buyer?
- Has the product or the manufacturer been given environmental/sustainability accreditation by an independent organisation?

Refer to the environmentally sustainable design strategies outlined on pages 123–6 and see if any of these have been applied by the designer and manufacturer of the product.

Sustainability in the classroom

Textiles

Choose fabrics carefully, such as:

- man-made cellulosic fibres such as Tencel (Tencel is lyocell, which is a 'non-polluting' type of rayon, compared with Bemberg, which is a cuprammonium rayon) and Modal
- fibres that have been certified, e.g. BCI (Better Cotton Initiative) cotton
- organic cotton – no herbicides or pesticides
- hemp and linen – fastest growing, low water demand, long-lasting fibres
- fabric from pre-loved clothing or other products.

Non-sustainable fibres

Choose fabrics carefully, such as:

- polyester, which is non-degradable and lasts forever
- fabrics treated (possibly with formaldehyde, which ranges from harmless to harmful, depending on the level) to make them non-iron, easy-care or wrinkle-free
- traditionally grown cotton – the chemicals required are harmful to the environment and to workers.

9780170400336

Wood

Choose timber carefully, such as:

- recycled or reclaimed timber
- plantation-grown timber with Forest Stewardship Certification

Mark out timber carefully to avoid waste. Keep scraps of reasonable size to use for trials or tests. Limit the amount of solid timber needed in your design and replace by better design, manufactured timber or metal. To protect timber in your product, use natural oils or water-based finishes.

Metal

Choose carefully. Metals are easily reused and recycled. Be mindful, however, of certain alloys that may not be. Keep all scraps to be reused or sent to recyclers.

Plastics

Choose carefully as plastics do not decompose. Look for plastics that can be recycled or plant-based ones that are biodegradable. Don't let small particles blow away. Before 3D printing of plastic, think carefully about whether your design is ready and whether it is necessary.

For further eco-design strategies for different materials, go to pages 124–6.

All materials

Deeper research can come from investigating material suppliers to see if they:

- treat farmers or workers fairly
- have reduced chemical use
- recycle water and use less of it.

Lay out your patterns carefully to make the most use of space. Think about joining methods so that, when your product is being disposed of, it can be taken apart easily and different materials can be separated. Make your product beautiful looking and good quality so that it is loved and lasts a long time. Add care or user instructions to prolong the life of the product.

REDEVELOPING A PRODUCT

Writing the design brief

To revise how to write a design brief, go to page 12. Once you have analysed the original/existing product to be redeveloped, you can write the design brief. Remember that in Unit 1 you are being asked to solve a problem related to the original product and improve its function/purpose and sustainability, and your design brief must reflect this.

As expected in all the VCE units, your design brief should cover relevant product design factors. The six most relevant to all products are:

- purpose, function and context (explain why it is being redeveloped and quality expected)
- user-centred design (specific needs of the user)
- visual, tactile and aesthetics (How should it look?)
- economics (expected finish date and budget, if applicable)
- material requirements
- sustainability (why it needs to be improved).

9780170400336

Examples of unsuitable product redevelopment for Unit 1

- Turning a pair of jeans into a carry bag by cutting them up and re-stitching them
- Turning a dining table into a shelving unit by removing the legs and adding shelves

These types of projects would be considered as reusing materials, not redeveloping a product. (However, it would be quite acceptable to construct your product from pre-used materials.)

Examples of suitable product redevelopment for Unit 1

- Analysing a pair of jeans, designing and making a new pair to be more sustainable by using organic denim, improving the quality of construction so they last longer, or changing the style so they are more current (i.e. change the waist height, the leg width, the colour of the top-stitching, the number and placement of the pockets, etc.)
- Analysing a piece of furniture, designing and making a new piece of a different size with improved ergonomics, more sustainable material, etc.

Your brief should cover only relevant product design factors, which depend on your product and design situation. Suggested ways to change the product's design include:

- changing the aesthetics by using the design principles and elements to better suit the user or a new **target market**
- improving the quality of the material and/or construction methods to impact on the life of the product
- changing, adding or subtracting some of the secondary functions to improve the product for a new target market or to better suit the user
- redesigning the product for disassembly
- omitting any components made from different material to that of the main material of the product, and designing and making all the new components out of the main material
- having detailed user care instructions permanently attached to increase the product's life span.

target market a defined group of people (grouped by age, income, location, interests, etc.) that is the focus of marketing to sell particular products

Include statements in your design brief as to which of the above changes you will be making to improve the product's sustainability and how this might occur. This will help when writing your evaluation criteria, and later your evaluation report.

Writing the evaluation criteria

To revise how to write evaluation criteria, go to page 19. Your evaluation criteria must reflect the important requirements from your design brief and the required changes to suit the end-user as well as the improved sustainability. They should also reflect other relevant product design factors in your brief as already mentioned. *Write your evaluation criteria in four parts as explained on pages 20–1 of Chapter 2.*

All evaluation criteria will be relevant for the finished product but only some will be suitable to apply to your design option drawings. *See the heading 'Evaluation criteria for design option drawings' on page 19.*

Workbook DFT: Evaluation criteria for design options

Aim to construct evaluation criteria for the finished product that:

- allow for an extended response
- are clear
- are specific to the product type.

9780170400336

Rather than writing an evaluation criterion as 'Is the redeveloped product more sustainable than the original?', it would be more helpful to write:

- 'Is my finished product more sustainable than the original design in its durability and in its ability to be repaired and recycled?'
- 'Were the sustainable materials that were chosen suitable for the product's purpose and situation?'

When it comes to writing a checking method for the product's sustainability, you may need to refer to information gained from your research. Ideally your product is more sustainable, so your evaluation will be checking how successful it is as an overall solution.

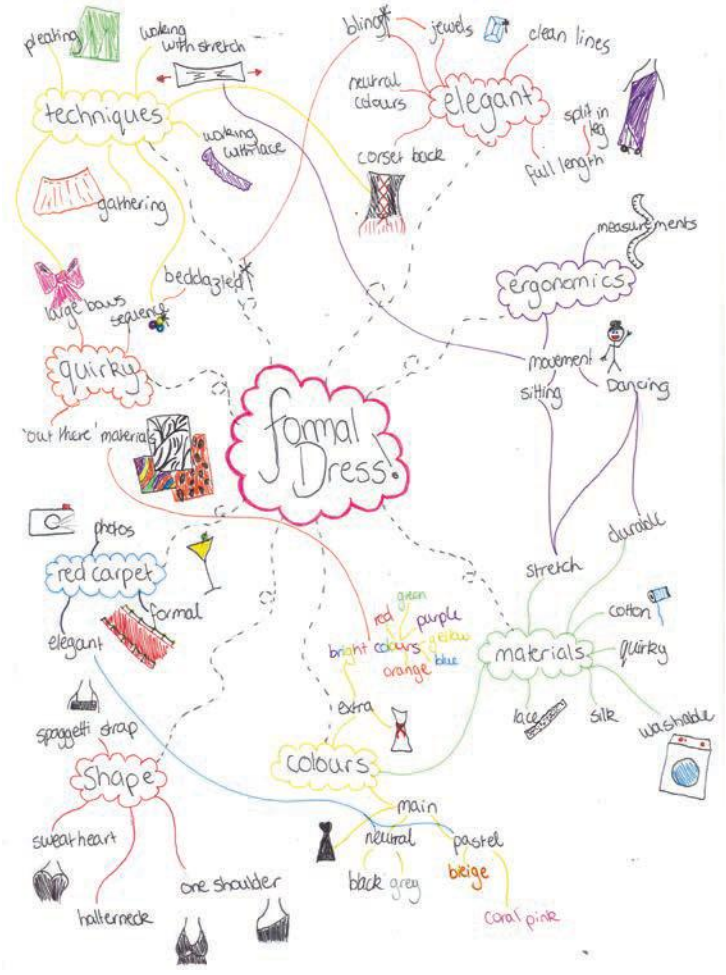
workbook DFT: research plan

Research

Research should include ideas for inspiration and relevant information related to materials, joins, finishes, ergonomics and sustainability practices. *To revise research and information gathering, go to page 21. To revise mood boards refer to page 56.*

Research for inspiration

Your research for inspiration will need to include a variety of ideas about and versions of the type of product you are redeveloping. You may also be inspired to take features from nature or from a totally unrelated product and add them to your new design, to change its aesthetics or its secondary functions. Think of the current most popular travel bags as an example of combining features from other products: they are a combination of a bag, a case and a trolley (not so long ago, all travellers had to carry, not wheel, their baggage).



Concept map to organise ideas, by student Shannon Milgate

Research for information

Your research for information may include ergonomics, suitable production processes, relevant measurements and the availability of materials and colours, etc. It should also include information on the sustainability of the existing product – particularly the material it is made from (if this is not covered in your product analysis) – and information on the sustainability of the material you intend to use. *To find out more about the source, origin and processing of materials, go to the materials-specific sections in Chapters 7 and 8.*

Use all of the methods outlined under 'Creative and critical thinking' on page 55 to help you stretch the possibilities in your redesign, including the list of triggers and the SCAMPER method on page 56.

Critical thinking

At this stage you have already used and will continue to use critical thinking techniques such as:

- asking questions to determine the situation for your design brief
- analysing products and materials to learn about their sustainability
- creating evaluation criteria and getting user feedback to select the best designs
- defining your skills to evaluate your capabilities
- researching availability of resources
- completing tests to observe and compare materials
- completing trials to check your capabilities and improve them
- turning creative or vague ideas into realistic and definite ones
- checking facts and making things definite.

DESIGN AND DEVELOPMENT

To revise design and development, go to page 28 in Chapter 2 and to Chapter 3.

Graphic organisers

Start your designing with idea exploration in a graphic organiser (a visual method of presenting ideas). Explore ideas to solve the brief, possible material requirements, areas to research such as costs and availability of materials, skills to learn, visual ideas and relevant sustainability practices.

For examples of a wide range of graphic organisers, go to the Enchanted Learning website, scroll down to 'Other Topics' and select 'Graphic Organizers'.

Or go to the Worksheetworks website and click on 'Miscellanea', then 'Graphic Organizers'.

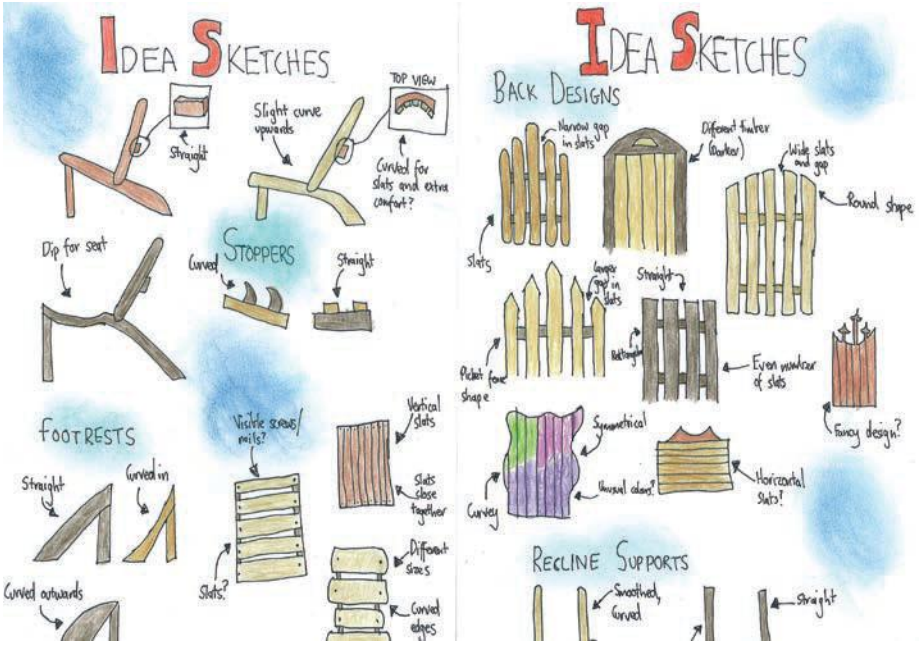
Links to both these websites have been provided at http://nelsonpdtvce.nelsonnet.com.au.

Visualisations

To 'visualise' ideas, you can use quick drawings such as idea sketches or thumbnails, mock-ups or 3D models.

In this first step of designing, include as many points of difference in your design from the original design as you can. You can select the best ones later. *Go to page 29 for more detail on visualisations, page 59 for wood, metal and plastics products and page 68 for textiles.*

Make sure you annotate your design ideas, explaining how they function and suit the user, changes from the original design, sustainability issues and features, etc.



Visualisations (idea sketches) to improve an outdoor seat, by student Steven Kearns

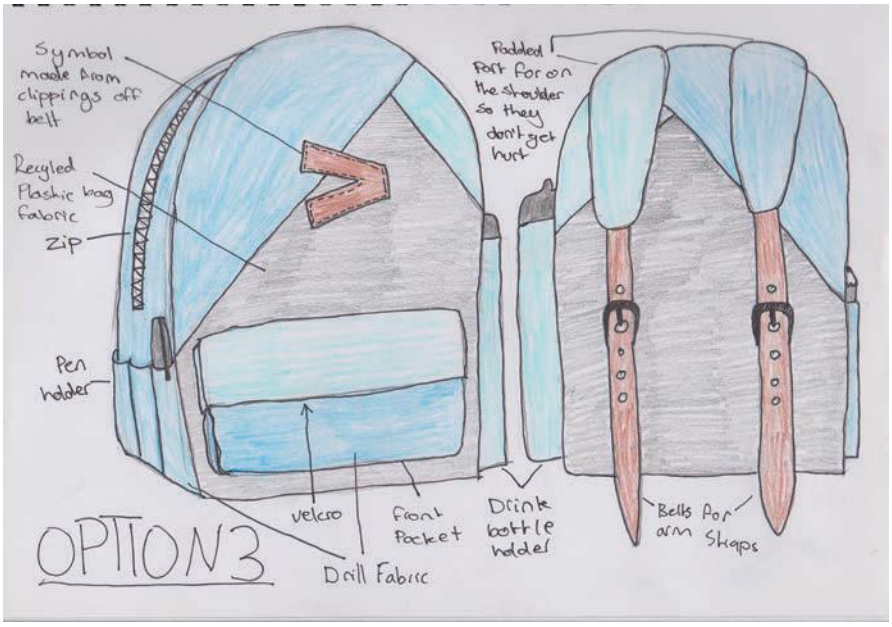
9780170400336

Design options (presentation drawings)

Go to page 30 for information about design options, page 61 for wood, metal and plastics presentation drawings and page 69 for textiles presentation drawings. From your visualisations, select the best ideas, combine them and create design options. Present each design option on its own page (the minimum size being A4), and number them clearly.

A presentation drawing is more detailed than a visualisation. Use bold outlines and colour to assist in the clarity of the drawing.

Annotations should reflect the points of difference and the improved sustainability. Your annotations should be clear and cover as many factors from the brief as possible.



An annotated design option of a bag, by student Elisabeth Roberts, showing the points of difference and improved sustainability intention

	Evaluation criteria	Score
1	Suitable colours?	/5
2	Suitable compartments?	/5
3	Quality construction methods?	/5
4	Adjustable straps?	/5
5	Suitable materials proposed?	/5
	Total	/25

An example for applying evaluation criteria to each backpack option

Select the preferred option

To revise selecting the preferred option, go to page 32.

Use your evaluation criteria to analyse your design options and to help select the preferred option. (You can rate each design out of 5 according to how well it satisfies each of the design option criterion.)

Some of your evaluation criteria will not be applicable to the design options, such as whether the product was finished to budget, on time, accurately or to fit the user. Only apply the criteria that are relevant to your drawings. You can abbreviate the relevant criteria and put them into a small grid to be placed next to each drawing. This will give you a method for scoring each option and comparing the scores.

If at all possible, use feedback from others to assist you. You may require a new drawing of the preferred option if it is a combination of features from the different design options.

Justification

Write a justification of why the preferred option was the best choice, explaining how it addresses each of your evaluation criteria. Usually this will be the option that scored the highest.

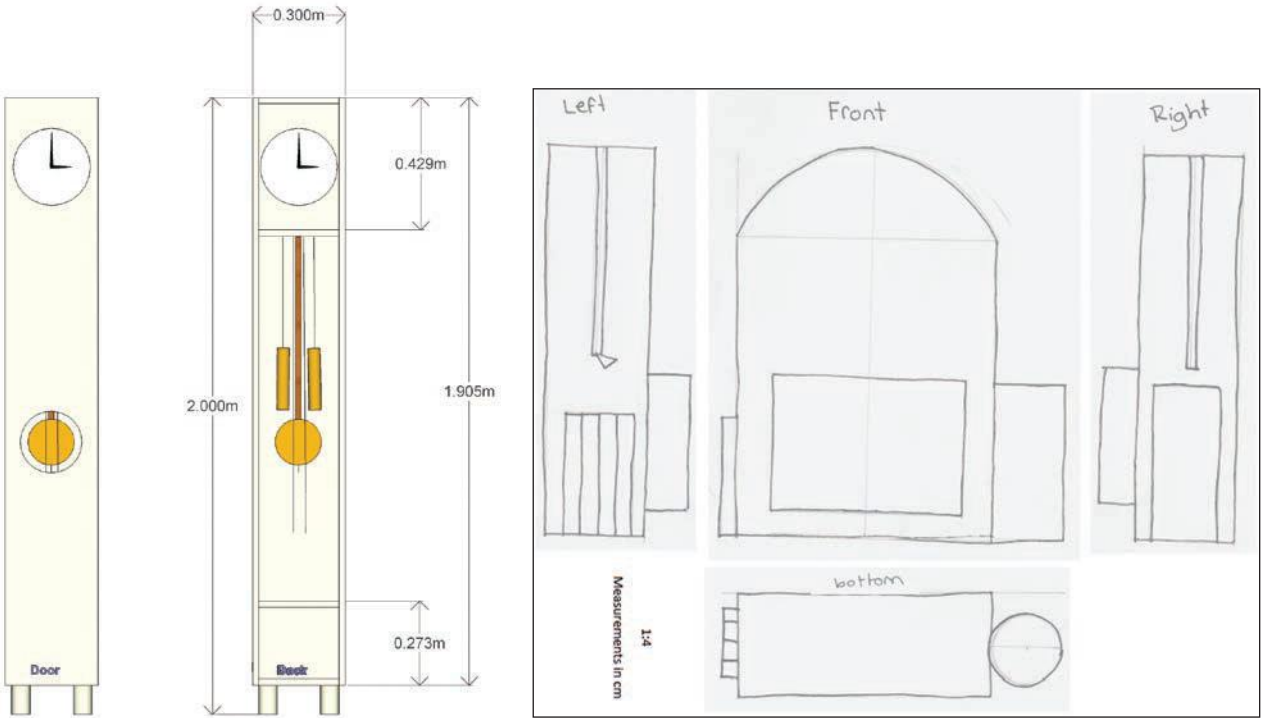
9780170400336

For example: 'Design option 2 for the backpack scored the highest with 21 out of 25. It is more suitably coloured and it will hold all the contents that it is needed to. It is also tall and the straps are situated in a better position for me than the existing one. The material [name it] I suggested is also suitable and will be more sustainable than the material [name it] used to make the existing product.'

Working drawings

Create appropriate working drawings of the preferred option. These help to define exact sizes and construction details.

To revise working drawings, go to page 33. Go to page 63 for wood, metal and plastics and page 71 for textiles. Look at the examples given in Chapter 15 for the SAT in Units 3 and 4.



Working drawing for a hall clock (left), by student Clark Fitton; working drawings for a backpack (right), by student Elisabeth Roberts

PLANNING AND PRODUCTION

To revise planning, go to page 36 and study the examples given.

Create appropriate plans to make your redeveloped product (see below and over the page).

Planning components

You are required to have:

- production steps
- a timeline
- a materials list with costs
- risk assessment
- quality measures.

9780170400336

Production steps

Refer to the basic steps of production (in the dot points below) and create at least 10 steps (as instructions to yourself) in order to construct your redeveloped product. Give an estimated time for each step and calculate the total number of hours for:

- preparing the material
- measuring and marking out
- cutting (or shaping/forming)
- joining (think of all the steps required for each join)
- attaching parts or embellishing/decorating
- assembling
- finishing.

Timeline

Create a timeline to show the date by which you should complete each step. Refer to the estimated time you have given each step and estimate how much you will complete in each workshop session. Find out the due date of your product and be sure to calculate the time needed carefully (total hours). It may be that your product is too simple for Unit 1, or too complicated for the time available and your skills. Adjust accordingly: add detail or complexity if the product is too simple; reduce some detail or complexity if it is too ambitious.

Risk assessment

It's important to complete this and have it checked by your teacher before you start any practical work. This includes tests and trials before production. You must demonstrate that you know exactly what safety precautions to use for any possible hazard.

Materials list with cost

Create this list by following your teacher's instructions.

Quality measures

In Unit 1, start with at least three quality measures related to your production. Choose from preparing, measuring and marking out material, cutting material and at least one joining method. Set out a table as follows:

Process (or part of the product)	Quality expected	Ways to achieve this
Preparing the material (name the exact material)	Clean, square, etc. (state what is important for your material)	Clean with … Check squareness by … Adjust by …
Measuring and marking out material (name the exact material)	Straight edges, aligned with the grain, accurate marking to 0.5 mm	Name the tools to do this accurately and other 'tips', e.g. Measure twice, cut once
Cutting material (name the exact material)	Straight edges, pieces to be of the exact same size	
Joining material (name the join and the material)	Joins (name the method) to be straight and to match up within 1 mm	

9780170400336

You can add to your quality measures throughout production as you learn more, and build on them in Unit 2 if working in the same material category. You can add more joining methods, any embellishing methods, attaching fasteners, assembly (if required) and the finishing processes you will use.

KNOWLEDGE OF MATERIALS

To revise the suitability, characteristics, properties and compatibility of materials, go to pages 114–16 in Chapter 4 and the relevant material section in Chapters 7 and 8. For more detailed information on sustainability, go to Chapter 5.

The choice of suitable materials is one of the critical decisions in the success of a product's design and sustainability.

In Unit 1, know and become familiar with at least two materials in your category that you could use in your redevelopment. You can then build on this knowledge in Units 2, 3 and 4. Get to know the materials thoroughly by:

- researching their origin or source
- researching the conversion technique that turns them into a useable form
- defining their characteristics and properties
- examining them through testing, trialling and comparison (see below)
- considering their suitability and safety (both for the maker and the user)
- outlining the environmental, economic and social impacts associated with their origin/source, manufacture, use and product disposal.

You do not need to treat the above as a checklist, as you may find that there is quite a lot of overlap.

Materials testing and trialling

To revise materials and suitable testing methods, go to Chapter 6 and study the examples given. Use the Internet to find information about a particular material's sustainability. Complete two specific trials on your materials for cutting and joining. Take photos and show the improvements to the quality of your work from your practice; i.e. of your first and subsequent attempts.

Create and report on a relevant test that compares the two materials that you will or could use. Tests and trials will assist you in understanding more about these materials.

Production

Follow your working drawings, plans and risk assessment to safely, efficiently and accurately produce your product.

Document your progress in a log or journal. This can be aided by taking photographs and adding captions. *To revise how to document your production process, go to page 46.*

Producing a prototype

Improving the product's sustainability may not be something you can achieve in the classroom, as it may depend on availability of materials, knowledge and facilities. It is acceptable that you create a finished prototype from alternative materials.

9780170400336

Student Nicole Crozier's 'prototype' demonstrates the complicated patchwork to be incorporated in a fully completed garment

Tamara Bottomly

Constructing a toile from check gingham

maquette
a small model made from substitute materials

A prototype is considered to be the final design of a product before it goes into production (of multiples). It is the piece against which all the important criteria are checked off, and is used if the product needs to be amended or modified (last-minute tweaks) before full production.

In industry, a series of prototypes will be designed, constructed and tested until the design is considered totally ready for production. Read more about prototypes online.

If you choose to construct a prototype, it is expected to be full scale, and to be a fully functioning product.

You may construct the prototype by using:

- recycled or pre-used materials
- less expensive materials or substitutes for costly, rare or precious ones
- materials that are easier to manipulate without sophisticated machinery.
- hand/lightweight machine production instead of industrial manufacturing processes

Some examples of prototypes are:

- a fully constructed garment made from low-quality materials and/or with small areas of high-intensity handiwork such as beading, embroidery, appliqué and an indication of how they would apply to the whole piece
- a piece of furniture made from pine or plywood – stained or painted to represent other materials
- the use of modelling foam, covered in plaster and painted to represent plastic or other materials
- a piece of jewellery made in silver or copper instead of gold.

Note that for the purposes of this study, a prototype is not the same as a mock-up, small model or **maquette**, which are smaller in scale, and are often used in the designing stage to work out proportions and how pattern pieces fit. A 'toile' for a garment, while full scale, may or may not be acceptable as a prototype, depending on the processes and materials involved. Check with your teacher.

9780170400336

EVALUATION

To revise evaluation, go to page 48. In Unit 1, you are required to evaluate your redeveloped product according to the evaluation criteria you wrote earlier in the process. A visual comparison with the original product will assist you. The evaluation report examines the success or not of your redeveloped product, its improved function or purpose and its sustainability.

Workbook DFT: Evaluation criteria for finished product

Comparison with the original product

A comparison of your redeveloped product with the original can be done visually. You will need an image of your original (this could be the annotated image from your original analysis) and a photograph (or a presentation drawing) of your product. Annotate the image of your product, explaining how it has been redeveloped (see more below).

Evaluation report

Start by applying the checking methods from your four-part evaluation criteria completed earlier in the process. In your report, explain how you checked the product and make a statement on the result. Include feedback from others if possible.

You may find that some of your evaluation questions can be responded to with 'yes' or 'no' answers. If so, then be sure to include an explanation and aim for an extended response, i.e. explain how well the product has satisfied the criterion. For example, if one of your evaluation questions is, 'Has the product been made more sustainable?' it is not acceptable to answer 'yes' or 'no'. You need to explain how and back it up by your research in your folio. Be sure to acknowledge the source of your information. If you take information from the Internet, you must include the name of the site, the URL and the date you sourced it.

If you have made a prototype, your evaluation should include an explanation of what material and finishes would be used in mass production, why these would be suitable and their sustainability consequences.

You may also decide that your product or prototype has not improved the sustainability of the original product. This is fine, but you must explain why not and any measures that could be taken to do so.

Complete the report by making suggestions to improve your product and methods further. You could comment on:

- **quality** – the suitability and accuracy of the processes (cutting, shaping, joining, finishing, etc.) that you carried out; how you avoided creating waste
- **time** – was your product finished in the time available? How effective was your use of design, planning and production time?

To improve your experience in Units 2, 3 and 4, make some comment on your research, design, planning and production activities and add suggestions for improvement.

9780170400336

CASE STUDY FOR UNIT 1

CASE STUDY

Schamburg + Alvisse

WHO ARE SCHAMBURG + ALVISSE?

'The idea that something is *expendable* or *valuable* is a point of view.'

This statement governs the design attitude of Schamburg + Alvisse, a Sydney-based furniture design studio. The studio was set up by architect Michael Alvisse and interior designer Marc Schamburg in 1997. Being expendable means something can easily be discarded as garbage. However, with a different outlook, its potential can be seen. Schamburg + Alvisse create many products of beauty that make good use of waste that is considered worthless by many. Clean, simple, innovative lines; durability and longevity; and meticulous attention to materials and finishes are combined to create great furniture.

Their premium quality work is considered so fantastically aesthetic and sustainable that it has won many Australian Good Designs awards; featured in prestigious local and international publications; been shown in museums in Italy and the United States and in permanent collections in both Sydney and Melbourne; and can be seen in many corporate offices and public buildings around Australia. In 2001 they were listed as among the world's 100 'most forward thinking product designers' in the book *Designing the 21st Century* by German publisher Taschen.

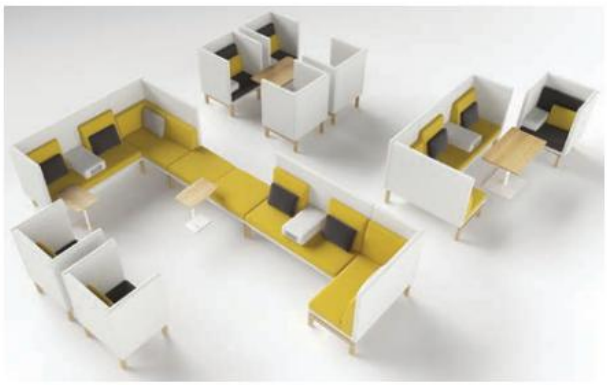
HOW IS YOUR WORK SUSTAINABLE?

Since the beginning, their furniture remains 100% Australian designed and proudly green throughout the design process to the end product. They have 'up-cycled' e-waste into A-grade products (see the *O-50* chair). They were the first Australian furniture manufacturer to be certified by the Forestry Stewardship Council (FSC) setting the now popular standard. Many of their seating products are also certified by the Australian Furnishings Research and Development Institute (AFRDI) for ergonomics, strength and durability. Their products are also certified by Good Environmental Choice Australia (GECA).

The furniture is made from various eco materials: FSC-rated timber, formed plywood, waste plastic, eco-foam, metal, glass, natural and reconstituted stone, woven fabric and leather.

WHY DID YOU JOIN WITH ZENITH INTERIORS?

In 2012, Schamburg + Alvisse joined forces with Zenith Interiors – a national interior corporate furniture company – a bold move that benefited both companies by allowing increased production and marketing scope within Australia and Asia. Products manufactured in Asia for the Australian market continue to be made to the same exacting standards as those mentioned above. The quality standards are met by thorough engineering, independent performance testing, tightly monitored quality control and experienced craftsmanship.



Courtesy Zenith Interiors

The *Edo* collaborative range

Courtesy Paul Gosney

The *3000* collaborative seating is typical of Schamburg + Alvisse modular furniture, which users can move and adjust as required

9780170400336

Courtesy Zenith Interiors

Mobius Modular

A STORY ABOUT ONE PARTICULAR PIECE OF FURNITURE?

The *O-50* chair (stands for 'Original 1950s') illustrates the company's typical sustainability practices and the inclusion of emotion and 'story' within the product. The *O-50* chair is a metaphor for up-cycling. It is a revamped 1950s design using only recycled materials. The concept evolved by Schamburg + Alvisse working closely with a Melbourne factory, which they connected with at a sustainability conference. Collected e-waste (discarded corporate ABS plastic waste such as computer casings, telephones and printer cartridges) is shredded. Through heat and pressure in an aluminium mould, the shredded mixture is reformed into a solid material called Recopol™. The Recopol™ is upholstered with fabric such as post-production offcuts, to create the *O-50* as new A-grade furniture. Where possible, the legs are fabricated from recycled material such as stainless steel tubing.

The chairs are purchased by major companies. For example, Westpac Bank liked the *O-50*'s eco-credentials and ordered 1200 of them for high-end executive seating. Since then, over 6500 of the *O-50* chairs have been produced, saving over 65 tonnes of e-waste from going to landfill – a great example of creating a product of value for offices from their own expendables.

Courtesy Object Gallery, NSW

O-50 chairs backed by a pile of typical waste they are constructed from

WHAT INSPIRES YOU?

'Inspiration is everywhere; open your eyes to see it!'

The duo maintain a keen observation of both the natural and built environments for inspiration. Collections or pieces are often named according to what triggered the idea. Some examples are:

- Watching water droplets, how they break and rejoin, inspired the *Stretch* collection.
- The shape and texture of pebbles worn smooth and rounded by water and time, and the way the pebbles nestled into patterns inspired the modular *Pebble* collection and the *Smooth* chairs.
- Natural crystal formation, in which atoms or molecules arrange themselves in a highly ordered, lattice-like structure, triggered ideas for the *3000* collaborative seating pieces.
- Radius edges of mobile phones inspired the *Smooth Tub* chair.
- The proportionately simple, intimately screened, box-like modules of Japanese streetscapes inspired the *Edo* collaborative seating.
- The mathematical concept of the Mobius strip, where a single line twists and changes face while continuing endlessly, was behind the *Mobius Modular* lounge.

9780170400336

DO YOU WORK FOR A CLIENT OR TOWARDS A TARGET MARKET?

'Many products have evolved from both inspiration and customer brief. A good example is the *3000* seating collection, which developed from both. It was initiated by the client (National Australia Bank) in their brief for collaborative high-back seating "pods" in their offices, inspired by the crystalline form seen in the architecture of WoodsBagot and guided by the Schamburg + Alvisse imperative for ergonomic performance and human comfort.'

DO YOU CREATE ONE-OFF PIECES?

Several unique one-off designs have been completed by Schamburg + Alvisse, including the six-part concept puzzle, *Stop Playing With Yourself* (*SPWY*), and the *Icon* lounge for the American Express Tower in Sydney. The design for these one-off pieces had to acknowledge the high level of hand-crafting involved to produce the limited quantity. Parts that required mechanised manufacturing processes (such as injection moulding for plastic chairs) prompted research early during the design phase to achieve cost-efficiency. Conversely, some manufacturing processes have also initiated product concepts. The *O-50* chair was designed to suit the specific plastic recycling process involved in creating Recopol™.

Schamburg + Alvisse offers custom designs to specific clients if the time required to develop them is acknowledged by the budget. Sometimes a one-off commissioned product has led to an ongoing production run, manufactured for years beyond the initial project. In these cases, the manufacturing process needs to be altered after the initial project completion to allow for special tools and mechanised processes. Some products don't allow for a smooth transition to higher volume processes and have therefore remained as a 'one-off'.

ANY DRAWING OR SKETCHING INVOLVED?

'We often sketch by hand on paper and we make a lot of simple hand miniature models from paper, clay or balsa-wood. Both methods form a lot of our preliminary 'play' and are great tools to pull an idea out of our head without committing to a rigid computer model.'

Courtesy John Weber

Stop Playing With Yourself furniture puzzle that requires collaboration to configure

9780170400336

COMPUTERISATION: WHAT ROLE DOES IT PLAY IN DESIGN?

'As most of our designs are very simple forms, the accuracy of computer modelling allows true form and proportional testing very early. However, we are also careful not to let the exacting detail required for computer modelling limit our design exploration too early.'

USER-CENTRED DESIGN

'We view design as powerful tools to build physical, social and spiritual "ergonomics": it is integral to human wellbeing. We are less interested in stand-alone objects and more interested in shaping the space and dynamics between people. Our eco-furniture satisfies practical considerations and delights the eye through elegant form.'

SOCIAL SUSTAINABILITY

Not only does Schamburg + Alvisse invest in environmentally sustainable practices, the business also invests huge consideration into social sustainability. Collaborative efforts are built on ethics and innovation. In 1999 they were offered a lucrative deal by GAP USA to furnish their stores with the *Stretch* stool. Having only just discovered through an independent eco-report that the material, although legal, was a likely neurotoxin for the craftspeople involved, they declined.

There is a long list of ways in which Schamburg + Alvisse puts back into the community including being an active contributor to public education for design, business, ethics and sustainability. This includes primary, secondary and tertiary education, particularly in New South Wales.

WHAT IS A TYPICAL DAY?

There are no typical days in a design practice like Schamburg + Alvisse. The designers aim to maintain openness for inspiration alongside awareness of the needs of changing environments. Any given day may see quiet contemplation and concept exploration balanced with research and collaborative problem-solving with their production team. Other days will be about their community work. A great balance!

Marc Schamburg spoke to Jacinta O'Leary in January 2017. You can read more about Schamburg + Alvisse and some short videos Marc created at http://nelsonpdtvce.nelsonnet.com.au.

9780170400336

Shutterstock.com/RTimpixer.com

CHAPTER 10

Unit 2: Collaborative design

CHAPTER FOCUS

In this chapter you will learn about:

- Collaboration and the product design process p. 268
- Researching a style or movement p. 270
- Approaches to teamwork p. 273
- Working as a team – including the use of digital technologies, investigating and defining the need, design and development, planning and production, and evaluation p. 275
- Presenting your work throughout the design process p. 284

Through case studies (from p. 285), you will also discover how designers work collaboratively.

COLLABORATION

The **product design process** is central to all the units in this study, but the major difference in Unit 2 is that you are required to work collaboratively. You will be given some parameters from your teacher, and from then on you need to work with your designated team.

Remember that the product design process is not a lockstep method:

- Some research may be required at any step.
- Evaluation may be required at any step.
- Both design options and products may require some more research or design tweaking to be finalised as viable solutions.

Each team needs to demonstrate, either in individual folios or in a team folio, how they worked through the design process for their situation. Each team member also needs to demonstrate their own input. While each student's input may not be of equal value, it should be a fair contribution. It is strongly suggested that you document evidence of your own input at each step and stage of the product design process.

To revise the product design process, go to Chapter 2.

9780170400336

THE PRODUCT DESIGN PROCESS

There are many steps or tasks that can be carried out by either the team or the individual, depending on the framework planned by your teacher, your team design situation and your approach to the product. The product design process in Unit 2 will need to include the following steps.

Planning the team task and approach, design brief and evaluation criteria

- Deciding what to make as a team
- Deciding on the style or movement to research and apply to the design work
- Nominating roles if necessary
- Constructing the design brief (including reference to user-centred design factors and related sustainability factors) with group and individual components (or separate individual design briefs, if appropriate)
- Constructing evaluation criteria to help select the preferred option, for the finished product, for the team effort and for the input of individual team members, along with checking methods for the finished product to see how it fulfils each criterion.

Research

- Carrying out research that focuses on user-centred factors, sustainability in relation to materials and a historical or cultural movement, using research activities that provide information from both primary and secondary sources (this may continue throughout the process). Specific research tasks can be completed by team members and then shared.

Design and development

- Creating visualisations: visual design ideas in either 2D or 3D that are annotated
- Creating presentation drawings: design options that are annotated, with reference to the team's style guidelines; providing evidence of creative and critical thinking, including feedback from team members
- Selecting a preferred option, with team feedback and a written justification that includes their comments
- Creating working drawings, showing the product's specifications.

Planning for production

- Creating scheduled production plans for the group and/or individuals (production steps, timelines, risk assessments, materials list, quality measures)

Carrying out production

- Applying risk management to make a product safely
- Documenting team and/or individual production, including photos where possible.

Evaluation

- Evaluating the finished product(s) with reference to the style or movement researched earlier, user-centred design factors and related sustainability factors, including observations and feedback from others, and suggestions for improvements.

9780170400336

The product design factors

In addition to understanding the product design process, it is vital that you understand the factors that influence and impact upon design. In particular, you are expected in Unit 2 not only to include the relevant product design factors, but also to make special reference to the user-centred design factor, sustainability and style/aesthetics. Re-read the relevant sections in Chapter 4 and consider how your team will address this. *User-centred design factors are discussed on page 96.*

Sustainability

Sustainability has been explained in Chapter 5 and, with reference to materials, in Chapters 7 and 8. Read through these explanations and become familiar with the idea of sustainability being the connection and interaction between social, economic and environmental issues.

In Unit 2, you are expected to develop evaluation criteria for your product and the materials used to determine its sustainability. This will require research and can be completed in the early stages of Unit 2.

RESEARCHING A STYLE OR MOVEMENT

Your team is required to learn about a specific historical or cultural movement, genre or style that relates to the theme, type of product, design situation or interests of the group members. That style could describe work done during a particular era or period (architecture, film, music, fashion), the design features of a design or art movement, or the individual style of a designer.

Some suggestions are: Bauhaus, Art Deco, Memphis, Minimalism, Organic Design style, Biomorphism, Oriental and Gothic (VCAA Study Design).

Use your research to help you create a unifying design approach or theme. When you research a style, genre or movement, you should define the factors that underpin it, asking:

- When and where did it occur or has it been most used?
- Are there significant designers associated with the style, genre, etc.?
- Does it have an ideological purpose; arise in response to a change in society or technology; or embrace a philosophy?

You also need to determine its specific design features:

- use of shape, colour, texture and line (the design elements and principles)
- use of materials
- the balance of, or emphasis on, aesthetics, form and function.

Alamy Stock Photo/Nikreate

Charles and Ray Eames' Modernist-styled chair and ottoman – just one of the genres of style you can research more about

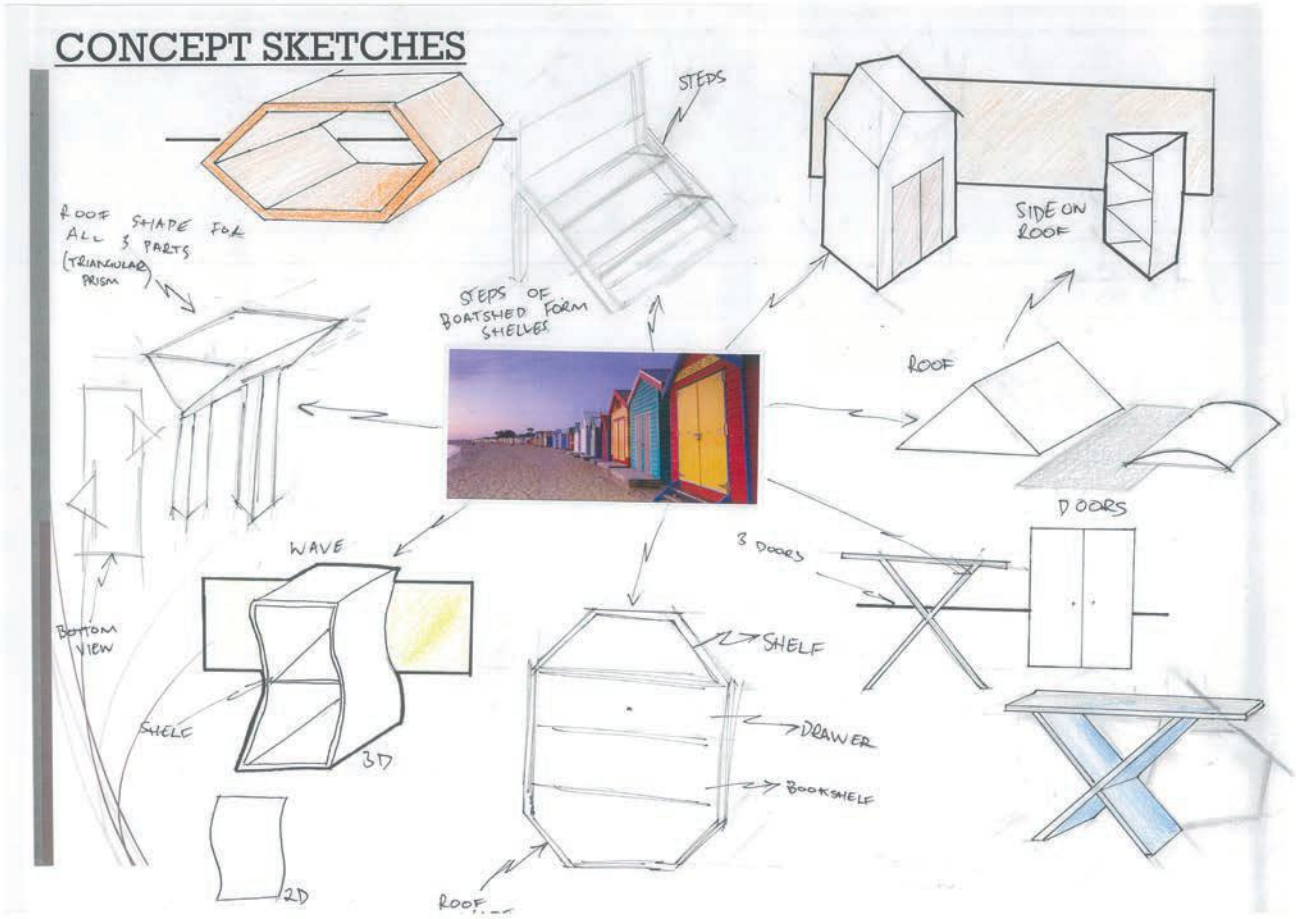
Chapter 11 gives you information about some of the styles in fashion and furniture design across the 20th century. You could use these as a starting point for choosing an appropriate style and then researching further. However, you are not limited to choosing from these styles – there are many other periods, styles, genres, movements and designers that might inspire your team.

Designers at the Italian fashion house Valentino collaborate with many artists and use many themes to inspire their work. *Read the case study of the range inspired by Christi Belcourt on page 285.* Other Valentino collections have been inspired by the works of Shakespeare (2016), African tribal culture (2015), traditional Chinese culture (2013) and a variety of artists or street culture.

9780170400336

Student Lian Wilson's collar ideas, inspired by exaggerated Shakespearean collars

Trialling the collar



Using Brighton Beach boxes as inspiration for visualisations, by student Josh Goudge

9780170400336

WHY TEAMWORK?

Each member should be encouraged to contribute to the team. Teamwork is considered beneficial for many reasons and is highly valued in industry:

- It brings multiple ideas and intellects together – people get inspired when working in close proximity to others with ideas, skills and knowledge.
- Team members can bounce ideas off others rather than making all the decisions in isolation. Teamwork in the same room also has the benefit of quick responses.
- The human brain is considered capable of holding only so much information at once, and human beings are only capable of carrying out certain activities in a given time. So, when the workload is distributed, it can speed things up.
- Through team interaction, more energy and enthusiasm is created, which can improve motivation and relieve monotony.
- Members can support each other. When working in a team, everyone in the group gains from the special capabilities and skills of the individuals in the group.
- Working as part of a team gives you practice at presenting – speaking up and explaining your ideas to others.
- Teamwork will improve your problem solving, reasoning, cooperative, speaking and listening skills.

Teamwork in design

Designers and makers pool their ideas, put forward suggestions (i.e. give constructive criticism), agree on certain aspects and inform each other according to their strengths.

Designers work increasingly as part of the team in a business setting. More companies now employ designers to work in-house, where they may never have had a design specialist before. The designer has to work with the business and its clients to solve problems. This can be a difficult situation, as they may be proposing a completely new way of doing things. It requires the designer to explain and justify their ideas clearly. Hopefully, this is one skill that you will improve upon while working in your team in Unit 2.

There are some strategies used in business that could help your team to function effectively:

- Set clear timelines and deadlines for particular tasks.
- Have a regular meeting time.
- Have clear roles for everyone within the team – make sure team members know what they need to do.
- Share your ideas with the team and ask for advice/input both in formal and informal situations.

Below is an example of teamwork in the commercial world of design, at Rip Curl.

Rip Curl

See the case study on Rip Curl on page 286. At Rip Curl, all the design and development team of the wetsuit division are passionate surfers who care deeply about surfing and wetsuits. They constantly compare, share, make suggestions and confer about how to create the best solutions. Prototypes are made downstairs from where the designers work, and superb surf is only minutes away, so it's quick and easy to share the information, and trial and test the product to get it right, with almost immediate feedback.

9780170400336

APPROACHES TO TEAMWORK

In Unit 2, you are required to do one of the following:

- Develop one product as a team.
- Use a production line to develop multiples of the one product as a team.
- Develop a product range as a team.

Developing a product as a team

This approach, where a group of students design and make components of a single product, requires careful planning. You need to be sure that the product can be finished in the time available. The product also needs to be substantial enough to allow input from each team member.

At the designing stage, there needs to be close collaboration to make sure that each student is thinking in the same direction. You will need to work out style, proportions and material, and agree on quality.

This approach means that each team member is required to make a part, or component of the product, or that team members each take responsibility for certain processes or stages within a product. It's important to plan carefully so that no-one is sitting around waiting to do their part.

Some suggestions for group projects are:

- an ornate costume for a play; a tailored jacket; or a fancy dress outfit
- a sporting outfit with matching accessories
- a reproduction chest of drawers
- a detailed wooden toy with moving mechanical parts
- a large fabric interactive play mat or game
- a storage box or unit with small compartments or stackable sections, made from different materials (wood, metal or plastic)

David Fletcher

Students from Huntingtower School apply the finishing touches to their collaborative project – a bus shelter with seat

9780170400336

- a gate with decorative elements
- a dividing screen with three segments (one made by each team member)
- a small bridge for a garden, for people to walk over
- a stepladder that doubles as a stool.

Students of Overnewton College, Keilor, worked in teams to make a range of seating for the school grounds, after agreeing on some design and aesthetic features related to the surroundings

Developing a production line product as a team

This approach is similar to the one on the previous page, but the entire team designs one product and then creates multiples using an 'assembly line' method. This allows those with particular skills to focus on them, and tasks can be divided up according to skill, or the desire to refine a skill. Each student then owns one version of the product.

Developing a product range as a team

product range
a group of products that are linked in some way, either by unifying design elements, the type of product, the material used, or a theme

A **product range** is defined as similar products, or different products with a similar look, colour, shape and feel, products that include the same material, or products that have the same function or purpose. In this approach, each team member gets to be fully responsible for a completed product, while learning to abide by the team's decisions in some way. The team should also agree on a style or movement to be influenced by. Some examples of a product range are:

- a range of children's clothes for summer by a small company
- a range of activewear for all seasons – gym pants (winter and summer), an athletic singlet, an athletic long-sleeved T-shirt, a jacket with pockets, shoes and a matching carry bag for sports gear
- a range of bedroom furniture, consisting of a bed base, bedside table and chest of drawers – all made from the same timber with the same stylistic features
- a range of jewellery – e.g. several rings in a similar style, or a set of jewellery (ring, bracelet, necklace and earrings) with the same recognisable features
- a range of two-drawer cabinets, made from the same material and with some unifying, stylistic features, but in different proportions to suit different storage needs
- a range of 'knock down' interior home office furniture or modular furniture that can be transported in a flat pack.

9780170400336

WORKING AS A TEAM

For teamwork to be effective, each member needs to:

- contribute and communicate frequently and effectively
- stick to decisions made (within the agreed group guidelines)
- ask for input from each team member and listen to their ideas
- be clear, but not insulting. Make constructive statements (i.e. how something could be improved) rather than simply criticising or being negative.

Unit 2 is aimed at preparing you for the workforce where, at some stage in your life, you will be expected to work in a team. Forget about how you, as an individual, want the finished product to be and concentrate more on the process. You might be very surprised by the result.

Use of digital technologies in your team

Many designers are located far from their clients or manufacturers. They use a wide variety of digital technologies to help them effectively communicate design work across an office, between states or around the globe. Read the case study of Rip Curl (page 286) to see how they use digital technologies collaboratively.

Wherever possible, create digital versions of your work in this unit to allow for easy sharing with team members. Some suggestions:

- Use Microsoft Word or Google docs for editing team documents, PDF files for final documents.
- Mind maps can be created in Word, PowerPoint or with specific applications.
- Illustrator or Photoshop can be used for both ideas and design options.
- Drawings done by hand can be scanned and a digital table added for others to give feedback (see 'Selecting the preferred option'). Scanned drawings can be manipulated and enhanced digitally captions can be added. Learn how to reduce the file size of images.
- Mood boards can be created digitally in PowerPoint, Word or other applications.
- Illustrator can be used to create technical 'flat' drawings for textiles.
- CAD can be used to create 2D and 3D technical drawings for wood, composite materials, metal and plastics.
- Use Microsoft Excel for timelines, costs, calculations, etc.
- Use 'cloud-based' servers, school drives or networks, email (using 'reply all') or social media to share files and feedback, so that everyone is kept up to date with information and discussions.

When preparing work for submission, it can be compiled digitally and presented in the order that best demonstrates the design process. To show individuals contributions, work can be colour-coded.

Access to team documents

If you are not working digitally, then be sure to photocopy all relevant documents and images for each team member. Also, consider keeping all folio items in a cardboard box or a designated cupboard, or on a pin board.

Creative and critical thinking

Creative thinking is about coming up with new and inventive possibilities, while critical thinking is sometimes defined as questioning, thinking clearly and making good decisions. Both are crucial for solving problems and discovering new knowledge. *Refer to the section on critical and creative thinking and techniques in Chapter 3.*

9780170400336

Creative thinking

One of the most important activities for a team is brainstorming, where each team member is required to contribute. A brainstorming session may only be needed at the beginning, but may also be useful throughout the process. Once a few directions have been decided on, individual team members can start to use other creative techniques to extend the ideas, such as **divergent thinking**, synectic thinking and the SCAMPER list of triggers (*see pages 53, 55 and 56)*.

divergent thinking considering a wide variety of ways in which a problem may be solved

Knowledge of the design elements and principles will assist you to communicate your visual ideas. Following up on feedback from team members could also help you to explore new direction in your designs.

Critical thinking

Critical thinking comes from asking questions, looking at ideas and their implications, and making constructive comments and judgements. As it is involved in narrowing down decisions, it involves **convergent thinking**. To be effective, it requires each team member to have a firm understanding of team goals and the requirements of the task.

convergent thinking bringing the most suitable ideas together

Sharing critical thoughts should not involve insulting the person from whom the idea came, but should focus on the positive and negative aspects of the idea being shared, and areas for improvement or modification.

It is important for the person whose ideas are being critiqued to listen carefully and think positively about differing opinions, without reacting defensively.

In a team, it is helpful to ask clarifying questions of each other. In response, members can refer to examples to assist in their justification.

Critical thinking requires you to check and evaluate sources of information for credibility: who is saying what, and for what reason? What are the facts or truth? That is why critical thinking is sometimes known as 'scientific thinking'.

Investigating and defining the need

Some suggested steps for investigating and defining the need are:

- Brainstorm
- Conduct initial research, particularly focusing on the user/s and their needs
- Set team goals
- Write the design brief
- Write the evaluation criteria
- Conduct further research.

Brainstorm

Your team should brainstorm collaboratively to decide:

- the team direction
- the approach (i.e. one product, production line, product range)
- the historical or cultural movement or style to be researched
- the user-centred design parameters to focus on.

9780170400336

Use graphic organisers

Use these tools at any stage to help organise or communicate ideas. *Revise their use on page 22 and look for more examples online.* Be sure to give a heading to indicate what the graphic is for.

Conduct initial research

User-centred design

Research aspects related particularly to the needs of the end-user/s of the product, how it might fit into or improve their lifestyle, details about how they might use the product, and issues such as ergonomics, safety and comfort. Read about user-centred design in Chapter 4 (pages 96–102) and see what is relevant to your group. Think about how research around the user can be incorporated into the design of your product or products.

Chosen style or movement

You need to decide on and research your chosen style or movement. Each member should gather at least one A3 page of text and/or images to share with the team. You can choose from the styles in Chapter 11, research them further online or choose others.

Sustainability

Start to gather sustainability information related to your team's work. Consider the methods, materials and components you will use. Consider how a product can be sustainable. Use information in Chapter 4, which briefly covers sustainability (as one of the product design factors), and Chapter 5, and the relevant pages in Chapters 6–8 for your material category.

Set team goals

No matter which approach is taken, some unifying points must be set down by the team collaboratively and early in the process, preferably in the design brief and evaluation criteria.

Write the design brief

Use the product design factors to assist you in writing the team design brief collaboratively. Be sure to include user-centred design parameters that are relevant, along with function, your chosen style's aesthetics, material requirements, sustainability, cost and time. *Go to Chapter 4 to revise the product design factors.*

Your team design brief needs input from all team members. *Go to page 12 to revise how to construct a design brief.*

It needs to be understood and agreed on by all. An individual section will need to be written for each member. Some team design briefs will be very clearly defined and detailed, while others will be much more open-ended with more detail in the individual members' design briefs.

Where possible, a design brief should take no more than one A4 page – it should be concise.

9780170400336

A sample design brief for Unit 2

Outline of context

My team consists of three people [name them]. We are going to make a range of products to do with 'Going to the races'. Every year our country town has a horse race. It is usually in spring when the weather is mild. People go in groups and take a small tent. Each year the standard of presentation of people's clothes and their tents has improved. We want to create a whole scene for our group of friends (usually 20 people) that outshines them all. We want 'tent furniture', furnishings, women's hats, tableware that all match. The style we have decided on to influence our work is Art Deco.

Each one of us will have a separate addition to the design brief, which explains our intended product, the end-user and their specific needs.

Constraints and considerations

- All products must suit the standards of the (country town) race wear and tents.
- They must all suit the needs of our group and the day (user-centred).
- They must be something new and creative for the group.
- The quality must be suitable to last the day.
- All products must be as sustainable as possible.
- The influencing style for all products is Art Deco.

Individual brief (two examples)

Example 1: My role is to design and create two hats for the females in the group.

They must:

- be adaptable to fit both large and small heads
- provide shade for the face
- aesthetically match the garments being designed by (name of team member/s)
- be suitable for the weather (which is ...)
- be easy to separate into parts so they can be reused
- be of materials that are easy to manipulate, comfortable and breathable.

Example 2: My role is to design and create a small stool that can be used by all group members in the tent. The stool design will then be made by some group members (or outsourced in low-volume production), so that we have enough stools for the day.

The stool must:

- match the theme
- be strong and stable but easily disassembled for storage
- be made of local hardwoods
- be smoothly finished to not catch clothing
- be able to be constructed at two different heights
- be easily portable for events.

Write the evaluation criteria

Evaluation criteria can be written collaboratively straight after the design brief is finalised, or after the research is completed. Evaluation criteria will be helpful to keep the group work unified and to keep the focus on the agreed objectives of the finished solution.

Each evaluation criterion for the finished product should be in four parts, as explained in Chapter 2:

1 Write each evaluation criterion as a question.
2 Give the reason for its importance or its existence in the design brief.

3 Suggest how the criterion can be achieved throughout the process.
4 Include a checking method for the finished product to see it if has satisfied the criterion.

Evaluation criteria for the design options can be simplified, but remember that not all will be answerable from drawings. See the table under 'Selecting the preferred option' on page 282 for how they could be shortened.

Evaluation criteria are written in two sections:

- Section 1 is for the team.
- Section 2 is for the individual.

Remember to include evaluation criteria for:

- relevant **Product Design Factors**
- the **user-centred design** factor relevant to each product
- the **sustainability** of the design and the materials being used
- the **use of a 'style'** to inspire the design(s).

Robyn Panousieris

Students Kieran Moran and Kalevi Viitala confer over their plans

Conduct further research

Your team must carry out further research, using both primary and secondary sources. Each member should carry out research and bring evidence of their findings to the team, e.g. one A3 page of research. *Go to Chapter 12, Unit 3, to revise primary and secondary sources.*

Remember that research needs to be defined for each member, be relevant and be done within a time frame. It could centre on ideas, data and/or information.

Research from **primary sources** could include:

primary sources sources of information that are obtained first-hand

- collecting different material samples and colours
- carrying out tests and trials on materials and processes for comparison and to determine suitability
- checking measurements of particular body parts or items
- observing activities around the design problem
- conducting surveys related to the design problem and talking to individuals
- using existing solutions to the design problem, and noting their strengths and weaknesses and how they could be improved
- taking photographs of relevant aspects.

Research from **secondary sources** could be:

secondary sources published accounts of information supplied by others

- collecting images of similar products from particular styles or movements from the Internet or publications
- gathering ergonomic or anthropometric data relevant to the user
- sourcing publications on the characteristics and properties of materials
- finding out about the sustainability of relevant materials from the Internet or publications.

Each team member should keep their own research file, as well as contributing to the group's research collection.

Knowledge of materials

In Unit 2 you will gain more understanding of materials and their characteristics and properties through using and trialling materials (primary sources). You are also expected to expand your knowledge of the sustainability of materials. This knowledge will be acquired from books and the Internet (secondary sources).

To revise the characteristics and properties of materials, go to Chapter 6.

9780170400336

Learning as much as you can about different materials will help you if you continue your study in design as an adult in the world. It will help you understand quality and value and will help you make informed purchases.

Attributing IP

Remember to make the name of the creator of any ideas clear and obvious to the viewer. Artists or designers from your chosen style need to be attributed. For factual information, quote the source. In a folio, it's a good idea to do this right next to the 'works'.

Remember that quoting Google Images, Pinterest and other social media sites does not constitute 'attributing the creator'. *See more on this in Chapter 4 on pages 108–9.*

Presenting your research

Wherever possible, present your research in a visual way. Consider using graphs, charts, material samples and diagrams. Look for ideas in Chapter 2. Improve your confidence by presenting your research verbally and visually to others, explaining your sources, decisions, images, etc.

Design and development

Go to page 28 for information on design and development and page 53 to read more about creative and critical thinking in the design and development stage. In this stage you can implement many of the digital technologies listed on page 275 to aid in communicating with your team.

Visualisations

Idea sketches and/or 3D models or mock-ups (visualisations) need to be shared and discussed before moving on to design options (presentation drawings). This is where annotation

Visualisations by student Jasmine Lee show links to her research on African themes

becomes important, as you need to justify or explain your ideas to others in your team and make note of their feedback. You should also show how your visualisations have been influenced by the style. You can do this by placing your own sketches right beside the images that influenced them.

This is also the stage where creative and critical thinking is mostly applied (*see later in this chapter*).

Mood boards

Mood boards can be helpful to keep the team focused on a theme. The mood board can define and be referred to for chosen team colours, lines, shapes, textures or 'moods'.

Mood boards, by students Demi Spyropoulos and Sophie Allen

Design options

Design options (drawn in the presentation style) need to be checked to see that the theme or style is understood in the same way by the whole group. For one group product, only one or two design options per member need to be created. For individual products, there should be two or more design options. *To revise the presentation type of drawing for design options and what is required, go to page 30.*

Annotate the design brief requirements, materials and construction methods.

9780170400336

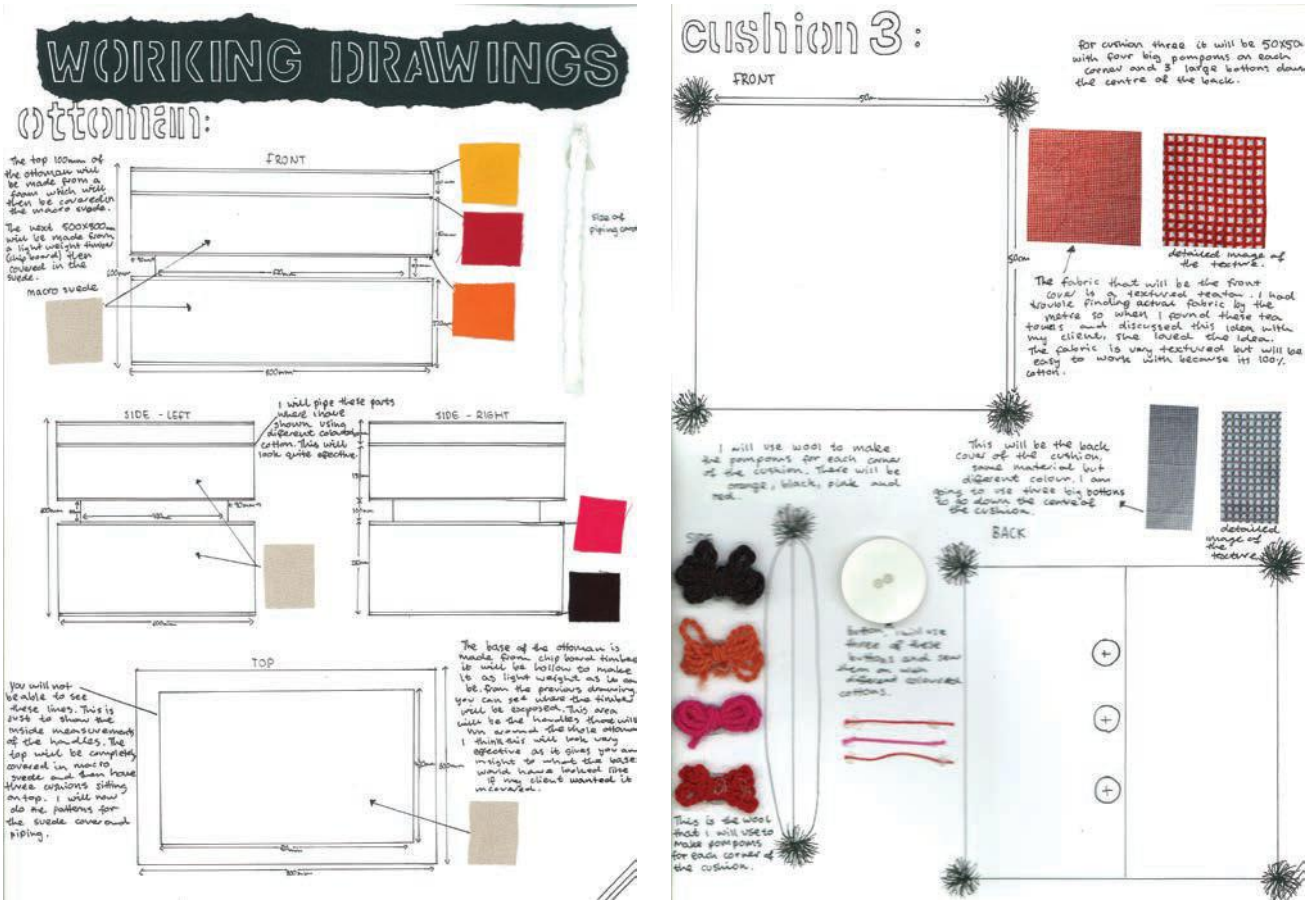
Selecting the preferred option

To revise how to select a preferred option, go to page 32.

The entire team should be involved in choosing the preferred option. Evaluation criteria can be used and scored out of five on each design option – add up and compare scores. Constructive comments (involving more critical thinking) are valuable here and can be used in the written justification.

Write your evaluation criteria in a small grid with columns for team feedback. This grid can be placed right beside your design option drawing and team feedback with a score written straight in.

	Evaluation criteria	Team member 1 [name]	Team member 2 [name]	Team member 3 [name]	Add extra columns if needed
1	Colours?	Too green! 2/5	Love it! 5/5	Neutral 3/5	
2	Function?	Clever! 5/5	Bit too complex! 2/5	Yes, clever! 5/5	
Total scores		**/30**	**/30**	**/30**	
Final score for Design Option 1					**/90**



Working drawings for an ottoman and cushions, by student Sophie Allen

9780170400336

Justification

For individual products, each member writes a justification of their preferred option using group feedback. If the team is working on one product, then the team should write a justification collaboratively, with a comment from each member.

Make it clear which drawing is the preferred option and how it satisfies the group and individual criteria.

Working drawings

Working drawings are required for the preferred option(s). They give the information required to make the product(s). This information is called the product specifications. *To revise working drawings go to page 33. Go to page 61 for wood, metal and plastics or page 69 for textiles.*

Planning and production

Scheduled production plans

To revise how to write the planning components, go to pages 36–47. Include the components of the production plan as follows.

Timeline

Once production steps have been created, draw up a timeline with dates, showing when each construction step of each team member is expected to be finished and the due date for the finished product. Make sure this work is coordinated, so that everyone has work to do at all times.

Production steps

If your team is working on one product, then a basic overview of construction will be needed, along with an individual plan of production steps for each team member. Teams working on individual products will each need their own plan of production steps.

Steps should cover: selecting and preparing material; measuring and marking out; cutting, shaping or forming; joining and the various steps involved; embellishing or decorating; assembling and finishing. Include the equipment needed and an estimated time for each step.

Materials list and costing

Draw up a list (including quantity) of materials and components, including their costs where relevant or when available.

Risk assessment

All team members should be aware of safety issues and create their own risk assessment chart. Information can be shared to save time, but each member must have one. Follow your teacher's instructions for this.

Quality measures

Agree as a team on standards of quality and make a checklist of what you want to achieve in specific terms. One team member can be assigned to be the quality controller. Use the quality measures you created in Unit 1 (*see page 260 also*) and build on them.

9780170400336

Production

During production, it's important to check that work follows team goals in terms of aesthetics, quality and safety. Plan as a group; share tasks, skills and knowledge; and support each other. Have regular discussions, and take photos of each member's contribution. Follow risk management for every step.

Log or journal

Each member should record their progress and caption photographs as evidence of work completed. Digital methods could be used to record your progress – think about using a blog, video, 'Photo Story', etc. Any changes to be made to the design or construction can be checked with team members for feedback, which should also be recorded in the journal.

Evaluation

Once your product(s) are finished, it is time to write your evaluation report. You have already written evaluation criteria, which will help you write your evaluation report. The section that follows explains the specific approach you need to take for Unit 2.

Evaluation is explained in detail on page 48.

Product evaluation report

When the product is finished, it is time to apply the checking methods to see how the product fulfils the evaluation criteria and the requirements of the design briefs (both team and individual).

Your report should also include observations and feedback from others. These questions will also help you write your evaluation report:

- How well did your product reflect the design movement or style that your team researched?
- Were elements of the chosen style used effectively?
- In what ways, and how well, does your product satisfy user-centred design factors (i.e. how well does it suit the end-user you were designing for)?
- How sustainable is your product (materials, waste, durability, recyclability, etc.)?

Make suggestions for improvements to:

- your product and how it could better satisfy the end-user identified in the team design brief
- the sustainability of the product and the materials used
- the application of stylistic elements from the influencing style or movement.

Although it is not required, you could comment on how well your team collaborated:

- Did members share ideas and communicate effectively?
- Was planning effective and production completed efficiently?
- Did you contribute well to the team's efforts?

PRESENTING YOUR WORK

Presenting and justifying your ideas to others throughout the design process is not only important in a team design project; it is an important skill to have in many walks of life. You can choose to present any aspect of your work in the design process to your team, or any aspect of your team's work to the rest of the class. The more often you do this, the easier it will become.

9780170400336

You may choose to prepare an electronic presentation. Your voice can be recorded over your text, images and drawings in many computer applications, and many programs allow you to write comments. A Microsoft PowerPoint or Prezi presentation will allow you to effectively show both images and text.

CASE STUDIES FOR UNIT 2

CASE STUDY

Valentino's Resort range, 2016

From indigenous beadwork to paintings to beautiful gowns – this is a typical line of inspiration that the designers of established Italian fashion house Valentino might follow. Maria Grazia Chiuri and Pierpaolo Piccioli (designers at Valentino) often look at artists' work from around the world for inspiration. In 2016, they created a Resort range in collaboration with Canadian artist Christi Belcourt, based on her painting *Water Song*. Belcourt belongs to the Métis people, one of Canada's Aboriginal groups, descended from Canadian First Nations people and early European settlers. She creates paintings inspired by the beadwork of the Métis and First Nation women of Canada. The beadwork is a highly skilled craft depicting colourful flora and fauna and is typically found on moccasins. Belcourt uses small dots in her paintings to convert the motifs from the beadwork into a colourful, patterned and magical world.

Beaded moccasins by Métis artisan Lisa Shepherd

Beaded moccasins by Métis artisan Lisa Shepherd

9780170400336

Anya Georgijevic, writing in *The Globe and Mail* in September 2015, said:

> Belcourt collaborated with the label's fabric research and development manager Francesco Bova, who worked from high-resolution photographs of the work (which is part of the National Gallery's permanent collection) to create luxurious floral prints and embroideries. Bova travelled to Toronto with fabric samples for Belcourt's approval before they were combined with Valentino's feminine silhouettes to create a striking assortment of garments from haltertops to evening gowns.
>
> While designer – artist collaborations have been popular since the days of Elsa Schiaparelli and Salvador Dalí, indigenous artwork has more often than not been appropriated without consent. 'When fashion designers raid the world's closets for inspiration, they often do so without permission,' says Susan Scafidi, founder of the Fashion Law Institute at Fordham Law School in New York City. 'Too literal copying of culturally significant designs can amount to cultural misappropriation.'

Belcourt accepted the proposition in 2015 because it was offered as a *collaborative* effort between herself and Valentino, *not* yet another example of blind cultural appropriation by the fashion industry, a controversial issue for years. She also loved their sustainability practices, rated number one by Greenpeace (Art of Dress website).

In March 2017, however, she was dismayed by the content of an article on the Native Appropriations online forum site. Written by Adrienne Keene, it recounted a story of finding a Valentino shoebox sporting a 'sacred' headdress or war bonnet. Belcourt was particularly saddened as she had spent time researching Valentino to check for any history of cultural misappropriation, such as having models walk down a runway in feathers or headdress. Belcourt was keen this information be included in her case study.

Getty Images/AP/Miguel Medina

Valentino dress inspired by Belcourt's *Water Song* painting

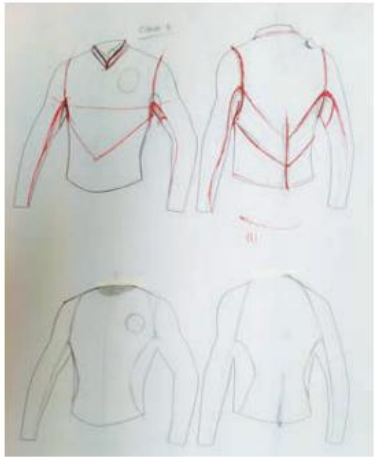
You can watch an informative video called *Water Song* on this collaboration and others at the Valentino website. A link to this website is provided at http://nelsonpdtvce.nelsonnet.com.au. To find more dresses from the range, try 'valentino resort 2016 belcourt' in an image search.

CASE STUDY

Rip Curl: wetsuit development

The global headquarters of Rip Curl is in Torquay, where it all began. The Rip Curl business was founded on wetsuits and they are still one of the core products, along with surfboards and watches.

Peter Coles is the Global Research and Development/Production Manager in the wetsuit division. All the wetsuit design and development happens in Torquay, and Peter's role is to assist with the development of new ranges of wetsuits. As well as working closely with the design and development team in Torquay, he looks after logistics, research and development (R&D), sourcing and production.



Rip Curl

Hand sketches for initial ideas

9780170400336

TEAMWORK

Getting a new wetsuit right and ready for market involves a whole chain of people – it is a great example of collaboration. Apart from Peter, the team in the wetsuit division consists of the chairman, a product manager (responsible for sales in the Australian region) and product managers in the northern hemisphere. John Pyburne, or 'Sparrow', is the pattern maker, and two designers, Jay and Maddison, look after wetsuit design and graphics, but there is significant input from the whole team. The team needs to approve concepts and ideas at various stages, and sign off before development continues.

FIELD TRIPS FOR NEW IDEAS

Field trips for Rip Curl designers might be as far afield as Indonesia, Manhattan, Sydney or Tokyo, where they do a lot of in-store checking. They check competitors' products and other types of sportswear, looking for new ideas that they might be able to bring into the wetsuit division, such as colour combinations, interesting seam lines, shape of the garment, construction techniques, finishings and trims. The wetsuit designs completed in Torquay are aimed at a world market. Each design has to satisfy users in different parts of the world.

DESIGNING AND PATTERN DRAFTING

Jay and Maddison often do hand sketching for initial ideas, and draw by hand straight onto a mannequin to see where the seam lines of a design lie on the body. Adobe Illustrator is used to refine and digitise those ideas.

The design is then marked out (drawn) onto an existing wetsuit for the pattern maker. Sparrow, the pattern maker, who has been working at Rip Curl for years, will create the pattern pieces on large pieces of brown paper (his workroom is filled with shaped pieces). He also cuts out the pattern pieces from the designated fabric. A prototype is made in the 'factory' workroom next door and given to a staff member to wear and test in the surf. This can be as immediate as that afternoon or the next day.

After the prototype has been used in the surf, feedback is given about:

- the fit – wetsuits need to be tight to be effective, but not too tight
- the neck – is the collar too high and choking, or too low and letting in too much water?
- flexibility in the elbows and knees
- the ease of getting it on and off.

Rip Curl

Lines are often drawn straight onto the mannequin in the Rip Curl design room

Rip Curl

The pattern maker cuts out pieces from neoprene

9780170400336

DIGITAL PATTERN GRADING

This initial prototype, usually made to a medium size, may be adjusted in minimal or numerous ways after it has been tested. Once the final prototype has had all its 'imperfections' ironed out, it needs to be graded (sized). Patterns are graded digitally using the Lectra CAD System, which is also used by the factories in Japan or Taiwan where production takes place.

To turn the paper patterns into digital form, the pattern pieces are taped with masking tape, one at a time, on a giant digitising board. The board has electronic grid lines (which are not visible). The computer operator goes over the outlines with a cordless digitising mouse and the shape is plotted accurately into the computer. For precision, only half of symmetrical pieces are 'scanned' and the computer program creates a mirror image of the exact dimensions for the other half.

Rip Curl has worked out its own grading system for wetsuits over many years to get the right fit for quite a range of different body proportions, limb lengths and sizes. Because a good, tight fit is important for wetsuits, the grading system is more complicated than for a product such as a T-shirt, where it might only be necessary to get the correct length and width measurements.

Grading patterns for wetsuits is not just a simple matter of enlarging or reducing (scaling up and down) all the pieces from the base medium size; it needs careful consideration of how all the pattern pieces interlock. Wetsuits don't have a straightforward back, front and sides that fit together. For example, they might have one piece that fits over the shoulder without seams. In this case an increase in upper-arm width for one grading may require a change in the shape and dimension of the shoulder shape in other sizes.

Rip Curl

Layers of pattern pieces that have been cut from neoprene

Once the pattern is graded, 'fit samples' (equivalent to final prototypes) have to be constructed to check that the design 'works' and all the bits fit together in every size. When all the graded pattern pieces have been finalised, the designs are emailed to the factory in Japan or Taiwan, where the majority of the wetsuits are made. This is a much faster system than was used at Rip Curl up until the early 1990s, when paper patterns with all their graded sizes for one design were rolled up and sent by normal post.

THE MACHINISTS

Rip Curl rash vests are machined in Torquay. It's important to have continual production work, so that the machinists are skilled up to make the prototypes and 'fit samples' when they are needed. Rash vests involve minimal labour, so it makes sense that they are the product to be made in Torquay, where labour costs are much higher than in Asia.

All repairs for Rip Curl wetsuits Australia-wide are done in Torquay. This is beneficial as it also provides work for the machinists and, apart from accidents (such as dog bites), it allows the company to check where wear and tear might occur.

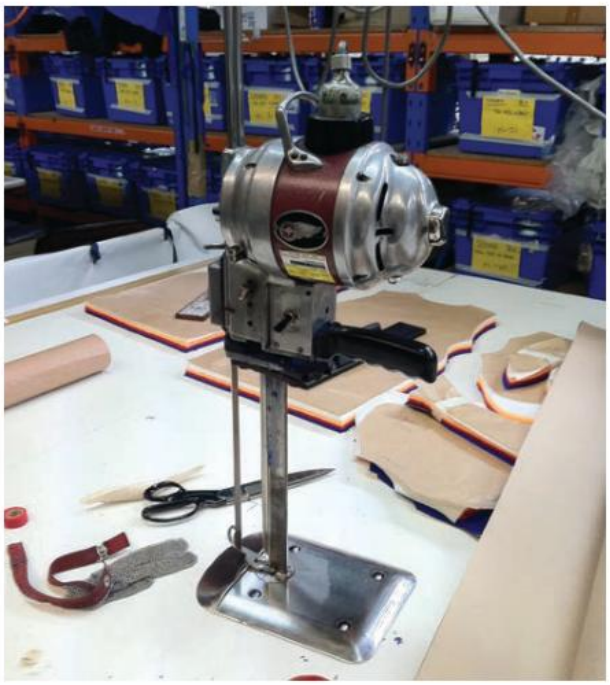
THE MAIN MATERIAL: NEOPRENE

The most expensive component of a wetsuit is the raw material, which is neoprene. Neoprene (chloroprene) has been used extensively in the footwear industry and in the automobile industry (as trims of doors and windows, car tyres and gaskets in the engine block) for decades. The price of neoprene is highly dependent on how the global automobile industry is tracking in terms of sales. When automobile sales are strong, suppliers' prices tend to spike. Unfortunately, Rip Curl has little control over this, as the demand for automobiles is far greater than for wetsuits!

The Lectra CAD system that Rip Curl uses can determine the yield for different fabrics, i.e. how much 2-millimetre or 3-millimetre neoprene is required for a wetsuit design. If the team can see on a prototype or via

9780170400336

the Lectra system that the patterns are not interlocking as well as they could, they will go back to the designer. Even though the design looks great, they might suggest adding a seam somewhere to get an extra 5 per cent efficiency in the use of fabric. They might suggest that instead of having a bump on the elbow, it could be tucked in a little bit to improve the yield.



Rip Curl

Various cutters are used on the neoprene

RESEARCH AND DEVELOPMENT

Rip Curl works very closely with the neoprene suppliers in Asia (where the bulk of neoprene comes from) for continual improvement and development.

At the moment, E4 neoprene and E5 flash lining are the latest incarnations of the world's most popular wetsuit materials and are used for the top-end range. Together they have maximum stretch, even less weight, great insulation and fast drying time. Two engineered layers funnel water rapidly out of the suit and, along with the double taped seams, provide maximum warmth and comfort. E4 evolved from the earlier E1, E2 and E3 neoprene, which were all developed in conjunction with the suppliers.

E1 neoprene was introduced in about 2000; it was roughly 2 millimetres thick, weighed 200 grams per square metre (gsm), and stretched at 100 per cent at 1 kilogram of force. Rip Curl is always working with the suppliers to push the material to the next level: to weigh even less, to stretch more and to provide more warmth. Suppliers work with the parameters and present several versions before it is 'right'.

IN-HOUSE R&D

Sheets of the 'new material' are sent to Torquay and wetsuit samples are made up. Rip Curl will test the materials internally with lab equipment and, more importantly (being near to Bells Beach and being keen surfers), staff will wear the wetsuits out surfing. They will closely document the number of hours in the surf

Rip Curl

A modulus machine for stretching neoprene

9780170400336

and do an appraisal on the material. In-surf test results are stacked up against the lab tests before a decision is made to commercialise the material or not.

The R&D performed at Torquay headquarters with the company's own lab equipment includes the following:

- UV is applied from a tungsten filament lamp to test the effect of sunlight on fabrics.
- A Rip Curl–engineered machine tests the endurance of fabrics in salt water. First, a sample is fixed at either end between two moving parts. They swish back and forth in a salt-water mix for a set amount of time or number of movements to continually elongate (and return) the fabric. This machine can be used to see how screen prints, laminated fabrics, glues and trims withstand this treatment.
- A modulus testing machine checks the elasticity of different laminates and fabric weights (in gsm). Samples that are tested are clearly labelled and filed.

QUALITY CONTROL

It is important to have quality control at the factories in Asia. Once the quality checklists and standard operating procedures (SOP) are in place, there is usually less need for stringent checking. However, quality control is always an issue as there are so many variables, such as the correct temperatures for bonding, etc. Variations can occur from batch to batch, so the product always needs to be checked.

TEAM FEEDBACK

Throughout the entire process of design, prototyping, pattern grading and production, staff feedback is most valued. Most of the staff have years of experience in surfing and in manufacturing, and are enthusiasts who have a tactile understanding of the fabrics from working with them and an intimate and experienced knowledge of what is required in the water. This is what sets Rip Curl above new companies in terms of 'fit for purpose' and quality.

Jacinta O'Leary spoke to Peter Coles in January 2017.

To see more about Rip Curl wetsuits and a video on their R&D, go to the Rip Curl website. Link via http://nelsonpdtvce.nelsonnet.com.au.

To find out more about the history of the company and wetsuit development, go to the Rip Curl website. Select 'About Rip Curl', then 'Company History', and then 'The Name "Rip Curl"' for downloadable documents. A link to the website has been provided at http://nelsonpdtvce.nelsonnet.com.au.

9780170400336

CHAPTER 11 Design inspiration

Shutterstock.com/Comaniciu Dan

CHAPTER FOCUS

In this chapter you will learn about:

- Using historical and cultural styles for design inspiration p. 291
- Fashion styles and trends – periods, features and key designers p. 292
- Australian fashion design: profiles p. 304
- Indigenous Australian fabric and textiles p. 314
- Furniture styles and trends – features, ideas and philosophies p. 316
- Australian furniture design: profiles p. 325
- Australian innovators p. 328

INSPIRED BY STYLES

Looking at the work of others is a useful strategy when thinking about what you like and don't like as a designer, what appeals to an end-user, what might work in a particular situation or setting, and different approaches to the same design problem.

The styles and movements described in this chapter are not exhaustive – there are many more 20th-century styles and designers than have been described here. You can also look at styles that occurred earlier than the 20th century, and designers and styles that are more current.

There are different ways of explaining and grouping designers. So, if you see designers and styles organised and described another way elsewhere, don't be concerned. Designers can, for example, be grouped according to their philosophy, their historical period, their location, their social environment or their common design features.

Cultural styles, movements and genres

The focus in this chapter is on historical styles, but there are some styles or movements that refer to a particular culture, community, sensibility or genre. Cultural styles often cross different media, design and art forms, and are created through some sort of social or philosophical connection. Some of these are discussed in the sections that follow, but there are others that are also valid to research and use as a basis for design work.

9780170400336

These include:

- Gothic
- Romantic
- Industrial
- Organic or naturalistic
- Minimalist
- Country/folk
- Futuristic
- Retro
- Kitsch
- Steampunk.

'Using' styles

Although it is really useful to research and refer to a historical/cultural style or the work of a designer in your design work, it is important not to 'copy' particular pieces. Copying is called **reproduction**, and this process doesn't teach you the creative development design skills you need. It also infringes the moral rights and the intellectual property rights of the designer. *To revise moral and intellectual property rights, go to page 108.*

reproduction a direct copy of something from the past (in terms of materials, construction and decorative details)

If you want to refer to a design style of a period or an individual designer, it is important to:

- research written information regarding how and why the style came about, and its philosophy
- look at a range of product images to get an idea of their design aesthetics (visual style, how the design elements and principles are used)
- recognise and list the common design features
- use some of these design features in your design work, putting them together in innovative and unique ways.

The sections that follow provide you with a starting point for your research.

FASHION STYLES

Fashion is usually defined in periods or decades. However, some significant or iconic styles, often led by a particular designer or design house, will thread through those multiple periods. Some fashion houses or designers have their own distinctive, consistent style or design approach that is less affected by changing fashions and fads. Fashion changes rapidly, so while the general design features for a period are indicated in the following discussions, these features may not be present in all clothing of that period.

1900s

Belle Époque a period of elegance and refinement often associated with French culture around the turn of the 20th century

Art Nouveau an ornate art and design style that uses flowing curves and lines based on natural forms

At the beginning of the 20th century, in a period called the **Belle Époque**, women in high society wore clothing that was opulent and lavish, with heavy use of lace and embroidery. Decorations showed the inspiration of **Art Nouveau** art and design features in the use of elegant curves, scrolls, organic lines, etc. The mature female silhouette was seen as the ideal shape; corsets pushing the hips back and the bust forward forced the body into an S-shaped curve. The suffragette movement developed during this time, and as some women became a little less tied to domestic work, they needed clothes for other activities – for travel and walking, 'appropriate' sports and driving.

Affluent men and women were required to change their clothing many times during the day to fit into strictly delineated dress codes. British King Edward VII's interest in fashion and clothing had some influence on the clothing styles of men during this time, while the working class benefited from the increasing industrialisation of fabric and clothing production, making stylish and refined clothing cheaper and more accessible. Ready-made clothing became more available in department stores.

9780170400336

Design features

- S-curve silhouette – the female shape is defined by corsets
- Highly decorated fabrics, lace, embroidery
- Different clothes for different activities
- Influence of Art Nouveau aesthetics
- The less formal lounge suit becomes acceptable for men's day wear.

Design features of the 1900s included the S-curve silhouette

1910s

Fashion design responded to significant art movements that abstracted shape and were more adventurous with colour. The sets and costumes designed for the great Russian ballet company, the radical Ballets Russes, also had considerable impact, with their strong colours, abstract geometric decoration, and oriental influences in clothing forms and shapes, decorations and accessories (e.g. turbans).

From 1910 onwards, the female silhouette became younger – more upright and cylindrical. While corsets were still used to give the body shape, bras were developed as an undergarment (although they were fairly shapeless and made from fine silk). World War I, which began in 1914, had the effect of lessening the formalities of clothing – voluntary work required more practical day wear and, for a time, the war reduced the obvious differences between the clothing of the privileged and that of the working class. Dance halls increased in popularity during and after the war, and this required more freedom of movement in evening dress.

The first half of the decade also saw the establishment of the men's suit – the form established then has continued right through the 20th century and up until the present day. During the middle to latter part of the 1910s, however, menswear was dominated by World War I uniforms.

Sorbet, skirt and tunic evening ensemble, by Paul Poiret (1879-1944). Satin and silk chiffon. Paris, France, 1912. Image © Victoria and Albert Museum, London

Paul Poiret's contributions to 20th-century fashion have been compared to Picasso's contributions to 20th-century art

Design features

- Simplified, cylindrical silhouette
- Until 1914 – dramatically shaped or flared thigh-length jackets, coats or drapes worn over cylindrical or tapered skirts (sometimes 'hobble' skirts, with buttons at the hem for movement)
- After 1914 – more functional clothing after the outbreak of World War I
- Stronger use of colour and contrasts – influence of Ballets Russes costumes
- Dress length rising from above the ankle to mid-calf by the end of the decade
- Long corsets (to give smooth cylindrical shape) and flimsy bras
- The establishment of the 'suit' as men's daytime clothing

9780170400336

Designers

- Paul Poiret
- Léon Bakst and Natalia Goncharova, who designed costumes for the Ballets Russes, and also contemporary artists, such as Pablo Picasso, Odilon Redon, André Derain and Henri Matisse

1920s

Art Deco
sleek, geometric design

In a decade that idolised youth and freedom, fashion came to be dominated by the young. Many of the restrictions and conventions that had come down from earlier periods in terms of behaviour and clothing were banished. The sleek geometric shaping and patterning of **Art Deco** (with an interest in luxurious textures and sheens) influenced the shape and fabric of garments. The silhouette of women's clothing was straight and tubular, with a dropped waist (defined at the hips with no waist shaping). It emphasised the young, undeveloped or androgynous figure, which was reinforced by binding the bust and cutting hair into a short bob. Evening dresses were shorter, with fullness below the drop waist or a layered 'handkerchief' hemline that allowed women to dance the Charleston and other vigorous jazz dance styles.

Sport became more important, and activities such as golf provided opportunities for men to wear more relaxed and casual clothing during the day (e.g. looser trousers or knickerbockers with a colourful patterned jumper).

Men's clothing of the 1920s was influenced by the fashions of popular sporting activities, such as golf

Design features

flapper
a term applied to a 'new breed' of young Western women who wore short skirts, bobbed their hair, listened to jazz, and flaunted their disdain for what was then considered acceptable behaviour

- Sheath silhouette, tubular, minimal body shaping (flat-chested, boy-like figure), **flapper** style
- Drop-waisted or no defined waist
- Use of more fluid fabric that falls over the body
- For evening wear – shimmering fabric, sequins attached to a filmy overlay
- Hemlines drop and then rise over the decade
- Increased use of make-up
- Emergence of the 'little black dress' (Chanel)

Designers

- Coco Chanel
- Paul Poiret
- Jean Patou

1930s

The 1930s was a period of social upheaval, starting with the Great Depression and ending with the outbreak of World War II in 1939. The Depression hit the Paris couturiers heavily, and they simplified their clothing (e.g. reduced the level of finely handcrafted work, making greater use of printed patterns) to make clothing cheaper and to reduce staffing costs.

Hollywood glamour became popular as an escape from the difficulties of daily life. The shape of the silhouette changed, with much more emphasis on natural curves. The waist returned to its natural position, bust binding was replaced with shaped bras, and the skirt flared gently. The ideal figure was still slim, but body contours were accentuated (particularly in evening wear) through the use of fine, clinging or highly sheened, softly draping fabric, cut on the bias. Designers were inspired by classical Greek sculpture, replicating the pleating, draping and revealing flow of fabric over the body. Plunging backlines also became popular.

An Elsa Schiaparelli dress from 1934 that uses draping and bias cut fabric to reveal the curves of the body

Latex was developed, enabling stretch undergarments, and the development of cheaper rayon made silk-like fabric more accessible. A healthy lifestyle was seen as important, and the wearing of short skirts, shorts and socks for sporting activities became acceptable for women. Swimwear became briefer and more figure-hugging, and tortoiseshell sunglasses were a popular accessory. Tailored trousers for day wear were prevalent in films but not widely adopted by women. For the first time, the height of hemlines changed according to the time of day.

For men, the double-breasted suit became popular. Menswear was also influenced by the style of the Duke of Windsor, who led change by holding his trousers up with a belt and using zippered flies (instead of braces and buttons).

Design features

- More feminine silhouette
- Figure revealed through silky fabric, bias cut, plunging backlines
- Influence of classical sculpture and surrealist art
- Hollywood glamour
- Shorter hemlines for day wear
- Increasingly revealing sportswear
- Innovation in fabric and fibre development – latex, improved rayon, permanent pleating

Designers

- Elsa Schiaparelli
- Cristóbal Balenciaga
- Jacques Fath
- Edward Molyneux
- Madeleine Vionnet
- Jean Patou

9780170400336

1939–45: World War II

Clothing during World War II was utilitarian, with extravagant decoration seen as wasteful and inappropriate. Fabric and clothing were strictly rationed, which meant that garments were designed to use the minimum amount of fabric, and reinventing older clothing became a necessity for many.

For men, double-breasted suit jackets disappeared, as single-breasted ones used less fabric. The female silhouette was cleanly defined, with broad shoulders, a fitted bodice, a natural or high waist (often delineated with a belt) and a gently flared skirt. Women's fashions reflected military styling, with structured shapes, padded shoulders and epaulets, classic and subdued colours, and military detailing. Clothing was functional, allowing women to move and work easily, and in the UK many designers banded together to create the mass-produced 'utility clothing' range. Leather was in short supply, so wood and cork were used as a replacement in the soles and heels of shoes (this was the beginning of the cork wedge). Silk and the new nylon stockings became a luxury, so women frequently 'bronzed' their legs and drew on the back seam with eyebrow pencil.

Some designers from French fashion houses escaped France before the Nazi occupation in 1940, but many salons were either closed or served the occupiers. This meant that Paris was no longer the centre of high and popular fashion – English and American designers dominated.

'Utility' fashion from 1943

Design features

- Simply cut, structured clothing, using the minimum amount of fabric
- Practical, functional clothing, including trousers for working women
- Clothing form follows natural body shape
- Military details
- Broad, padded shoulders
- Subdued colours
- Use of cork and wooden heels on shoes

Designers

- Cristóbal Balenciaga
- Jacques Fath
- Nina Ricci
- Elsa Schiaparelli
- Members of the Incorporated Society of London Fashion Designers – e.g. Hardy Amies, Digby Morton, Worth (London), Edward Molyneux
- Claire McCardell

9780170400336

1947–57

Although clothing and fabric rationing continued in the UK and Europe until the end of the 1940s, there was a move away from the austere, military-based fashions of the war during this period. Paris reasserted itself as the centre for haute couture, while the USA dominated the ready-to-wear market.

In 1947, the collection by newcomer Dior was dubbed the 'New Look'. It was a dramatic change from the previous decade, with Dior's emphasis on soft shoulder lines, tight waists (requiring the corset-like 'guepiere', 'waspie' or bustier) and flared skirts. Dior started a trend for very dramatic clothing design that used strong, structural shapes, extravagant quantities of fabric, and luxurious textures. Many of his letter-named collections (e.g. the A, H and Y lines) significantly changed the shape of the silhouette during the 1950s, and styles became almost architectural in their form and construction. Accessories were important during this period, with hats becoming more abstract in shape.

When Chanel was relaunched in 1954 (her fashion house had closed during World War II) she took a different approach, disdaining the prevailing highly structured and 'corseted' styles, and reinvigorating her classic designs. The Chanel suit (with a short, simply shaped jacket and a straight skirt) became the 'uniform' for female office workers in the late 50s and 60s.

An emphasis on sportswear returned (it had been viewed as frivolous during the war) and the controversially scanty bikini was launched in 1946. Greater access to nylon meant that synthetic lingerie could be structural (girdles) or silky, lightweight and drip-dry.

Design features

- Tightly constrained waists
- Full hips with dramatically flared skirts, or tight, pencil skirts with a back pleat or vent
- Soft, sloping, unstructured shoulder lines, or strapless for evening wear
- Use of contrasts
- Strong, dramatic details (sashes, bows on the hip, collars) and accessories (hats, gloves, muffs, stoles)
- The 'swing' coat
- The Chanel suit

Designers

- Christian Dior
- Cristóbal Balenciaga
- Jacques Fath
- Pierre Balmain
- Coco Chanel

© The Metropolitan Museum of Art. Photo: Art Resource, NY

Bar Suit by Christian Dior (1947)

9780170400336

Teenagers

In the mid-1950s, a distinctive style of fashion was developed for teenagers (a segment of society that hadn't been recognised before). For teenage girls, the shapes of the fashion houses were converted into a lighter, less formal look, with nipped-in waists, knee-length pleated or flared circular skirts, a looser bodice, and unstructured, soft jackets and cardigans, worn with flat shoes and 'bobby socks'.

Teenage boys also developed their own style, with slim-line jackets, drainpipe pants and narrow ties, or the more rebellious James Dean or Marlon Brando look: jeans, T-shirt and leather jacket.

Getty Images/Classic Stock/Debrocke

'Teenage' fashion began in the 1950s

1957–67: Into the 'Swinging Sixties'

After Dior's sudden death in 1957, the young Yves Saint Laurent continued the dramatic directions of the Dior fashion house. He developed soft, belted, long, lean dresses (the 'sack') and A-line trapeze shapes. Founding his own fashion house in 1961, he borrowed from men's clothing in his designs for women, including the trench coat, the safari suit and the influential 'Le Smoking' tuxedo suit. He also reflected art styles in his designs, using colours, shapes and patterns from the painter Piet Mondrian and from **Pop Art**.

Pop Art
popular and commercial art and culture

Givenchy and Balenciaga continued to make refined clothing. Givenchy's designs, much loved by Audrey Hepburn, were sleek and classic, whereas Balenciaga played with exaggerated geometric shapes. Pierre Cardin experimented with enormous creative collars, asymmetrical necklines and spherical shapes; his inspirations drew on Pop and **Op Art** images, and showed connections to space exploration.

Op Art
uses strong abstract and geometric shapes; often creates optical illusions

Getty Images/Condé Nast/Henry Clarke

An example of Balenciaga's dramatic shaping during the 1960s

However, the dominance of Paris-led haute couture fashion declined – there were fewer affluent women to buy the increasingly expensive, labour-intensive clothing. Italy developed creative, modern designers who broke away from the norms of shape, texture and patterning. It became the centre for men's tailoring, with 'sharp' suit styling (short jackets, straight-cut pants, narrow ties and pointed shoes) that quickly spread through Europe, the UK and to the USA. The stylish First Lady, Jackie Kennedy, boosted the popularity of American fashion designers, with her

elegant and minimalist suits and sheath dresses. *See the Yves Saint Laurent dress from 1965–66 in Chapter 2, page 24.*

A new wave of English designers arose, led by Mary Quant, who created simple, strongly coloured shift and tubular dresses, worn with opaque tights and few accessories. Hemlines became increasingly short. Quant marketed the whole look, developing make-up, tights and shoes, and used a range of new synthetic materials, including PVC for shoes and boots. Her approach rejected the stuffy and formal fashion establishment, and was aimed towards the young.

The late 1960s saw a shift to longer jackets and coats worn over skirts, and a revival of the slinky satins and trousers of 1930s styling. Clothing became more unisex, with a crossover of trousers, jeans and sweaters.

Design features

- Ideal of the young, waif-like figure: very slim, no curves
- Silhouette based on simple geometric shapes – boxy, rectangular straight shifts, triangular trapeze dresses and 'puffball' spherical shapes
- Shorter hemlines – the miniskirt
- Block colours and strong contrasts
- Dramatic patterns
- Tactile clothing – playing around with textures
- 'Sharper' styling for men's suits – small lapels, straight trousers with no pleats, narrow ties
- Influence of art styles – Pop and Op Art artists, and other modernist, abstract artists

Designers

- Yves Saint Laurent
- Pierre Cardin
- Hubert de Givenchy
- Valentino
- Mary Quant

1970s

The fun-loving 1960s gradually gave way to the more cynical and rebellious 70s. In the late 60s, protest movements opposing the Vietnam War, student riots in the USA and France, an increased awareness of drug use, and the feminist movement all fed into an anti-establishment counterculture.

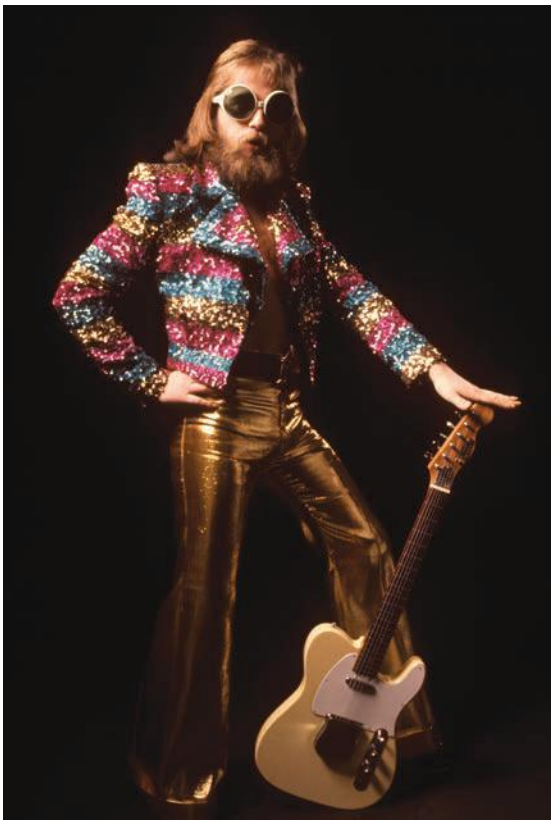
Although miniskirts were still popular at the start of the 1970s, gradually the clothing styles of the left-wing, liberal hippies were adopted more generally. This style of clothing showed influences from the indigenous cultures of the Americas and India, and also from the 'back to nature' stance of the growing environmental movement.

Everyday clothing became more casual, often long and flowing (midi and maxi dresses became popular) and used natural fabrics (e.g. cotton, leather and suede). Fringes and embroidery decorated many garments, and handcrafting – particularly knitting, crochet and patchwork – was rediscovered. Both genders grew long hair that was left to be 'natural', rather than carefully tamed, and male and female clothing became very similar (e.g. women wore jeans and pants, while men wore short and long kaftans).

Design features

- Midi and maxi lengths
- Ethnic influences
- Handcrafted and natural fabrics
- Less gender-specific clothing

9780170400336



Getty Images/Tony Russell

The glitter and shine of glam rock fashion

Getty Images/Chicago History Museum

High-end evening dress made from soft draping silk jersey

Designers

- Zandra Rhodes
- Bill Gibb

Glam rock

In the later 1970s, glam rock styling had some influence on popular fashions, with its shiny and ostentatious fabrics (fake fur, leather, satin, etc.), tight body shaping, chunky high platform shoes and boots, lots of metallics, black and strong colours, wide belts and strong make-up. There were some references to Hollywood/cabaret-style glamour.

Design features

- Flamboyant fabrics
- Tight body shaping and platform shoes
- Strong make-up

Designer

- Yohji Yamamoto

High-end fashion

During this period, Balenciaga closed his salon and Chanel died, but high-end fashion continued, predominantly in Paris, Milan and New York (although with fewer clients). Saint Laurent contrasted some provocative designs alongside his more classic styles, and incorporated some of the handcrafting techniques that had become popular. In the early 1970s, he also showed an interest in 1940s styles. Cardin played around with styles that were longer, using softly draping jersey, fringing and handkerchief hemlines. There were newcomers on the field, including Lagerfeld, Armani, Versace, and a number of Japanese designers, including Hanae Mori and Issey Miyake. To survive, many designers and fashion houses developed more accessible ready-to wear ranges alongside their haute couture collections.

Designers

- Yves Saint Laurent
- Pierre Cardin
- Versace and Armani
- Lagerfeld
- Moschino
- Hanae Mori, Issey Miyake
- Calvin Klein, Geoffrey Beene, Halston

9780170400336

1980s

The haute couture fashion houses at this time were thought to have only about 3000 customers worldwide, of whom approximately 600 bought clothing regularly. However, the couture collections had a trickle-down effect on ready-to-wear clothing, and the fashion houses survived on licensing their names to a wide range of luxury products, particularly perfume and accessories.

High-end designers in the 1980s

- Calvin Klein
- Giorgio Armani
- Gianni Versace
- Vivienne Westwood and Malcolm McLaren
- Zandra Rhodes
- John Galliano
- Jean Paul Gaultier
- Karl Lagerfeld
- Christian Lacroix
- Ottavio Missoni
- Yohji Yamamoto
- Issey Miyake

Bustier, designed 1980 (plastic), Miyake, Issey (b.1938) / Philadelphia Museum of Art, Pennsylvania, PA, USA / Purchased with the Costume and Textiles Revolving Fund, 1992 / Bridgeman Images

Bustier by Issey Miyake

1980s influences

Diana, Princess of Wales, was viewed as a fashion leader, and moved from the pearls and frilly-blouse 'Sloane' style and highly romantic wedding dress to the more glamorous and sophisticated clothing of British couturiers. The 1980s also saw an increase in the importance and influence of Japanese designers, as they incorporated a different sensibility to the structure of clothing and how it fits the body, and the use of fabrics and decorative techniques.

1980s styles

The popular clothing styles of the 1980s were split into three main streams:

- power dressing
- the New Romantics
- punk.

Power dressing

Power dressing was about women finding a stronger place in the traditionally masculine corporate world. Women's styles adopted men's clothing pieces: suit jackets, tailored trousers, shirts (either crisp or softly draping) and coats. Skirts were above the knee and pencil thin. Broad shoulders were balanced with a waist that was often pulled in with a wide belt.

Design features

- Big, padded shoulders
- Suits with full trousers or pencil skirts
- Conservative colours and fabrics
- Minimal accessories

9780170400336

Alamy Stock Photo/Trinity Mirror/Mirrorpix

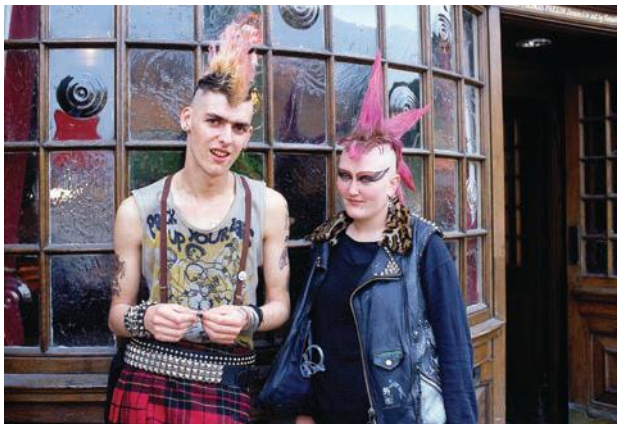
The New Romantic band, Spandau Ballet

The New Romantics

Closely related to music, the New Romantics style (mainly based in the UK) incorporated clothing that was based on a romanticised version of past eras, using luxurious, glamorous fabrics with extravagant styling. Men took on a pirate or 'foppish' look. Their flamboyant clothing and long, well-styled hair and make-up led to a sense of gender ambiguity. Romanticism also crept into more conservative everyday wear – with frilled and pintucked shirts, and dresses with tight bodices, full sleeves and skirts – and the fine floral-print fabric of clothing companies such as Laura Ashley harked back to pre-1900 styling.

Design features

- Styles of fantasy or past eras, with glamour and flamboyance
- Men: long, well-styled hair and make-up
- Full-sleeved silky shirts and theatrical jackets
- Luxurious fabrics
- Extravagant use of fabrics, including frills



Alamy Stock Photo/Interfoto

Anarchic fashion connected to punk rock

Punk

The rise of punk came out of disillusionment with society's structures and aspirations. In fashion, punk also showed a rebellion against the safe, classic styling of fashion houses and department store clothing, and was intentionally out to shock.

Inspired by the anarchic rage of punk rock music and the styles of Vivienne Westwood and Malcolm McLaren, most punk clothing was homemade, sourced from op shops, and then slashed, worn in layers, and heavily decorated with provocative and obscene words and phrases, and with chains, studs and safety pins. The body was also pierced in non-traditional ways, make-up was heavy and dark, and hair was straggly, shaved or 'glued' into brightly coloured Mohawk spikes. Doc Martens were the shoes of choice. Some components of punk styling crept into fashion house design in a selective, restrained way.

In the mid-80s, Vivienne Westwood moved away from her punk origins and created collections of creative, still slightly subversive, designs for the Paris catwalks.

Design features

- Scavenged clothing, slashed and torn
- Use of chains, studs and safety pins, on clothing and the body
- Predominantly black
- Leather and PVC
- Tight black pants, or miniskirts with torn fishnet tights
- Heavy make-up and spiked hair

9780170400336

1990s

It is harder to define common themes or styles in the 1990s, apart from a broad eclecticism. Catwalk designers were influenced by street styles (hippie, surf, rap) and non-Western cultures (particularly Asia and the Middle East), and often reflected the broad ethnic background of new designers. Generally, clothing became more fitted to the body, and a greater use of softly draping knits and sheers revealed its natural shape. Conservative designers rejected the conspicuous consumption of the 1980s, and work clothing for men and women became softer, less focused on power, and more casual. A more casual approach to clothing generally also meant that sportswear, such as the tracksuit, became more commonly used for everyday clothing. The environmental movement returned, encouraging the use of natural fabrics, the recycling and reinventing of clothing, and the anti-fur movement.

Grunge

One of the strongest street styles to emerge was grunge, again coming from a particular rock music style. In clothing, the trend merged the punks and the hippies. Vintage and op shop finds suited a style that rejected consumerism, and the high-end couturiers that assimilated some of its features were seen as 'posers'.

Design features

- Loose and shapeless clothing
- Checked shirts, ripped and dirty jeans
- Messy or dreadlocked hair
- Big jackets worn over tight crop tops and ripped-off shorts or baggy jeans
- Light floral dresses and chokers, teamed with heavy boots
- Doc Martens returned

High-end fashion

Accessories such as bags – particularly those made under licence to the high-end fashion houses – were highly prized (and exorbitantly priced). The celebrity of 'supermodels' developed, and their notoriety increased the profile of the fashion houses that clothed them. Fashion houses also survived by developing 'diffusion lines' – less expensive, everyday collections developed and licensed to department and chain stores (e.g. McCartney for Target).

Getty Images/Annamaria DiSanto/WireImage

Grunge style

Getty Images/Chicago History Museum

Issey Miyake high-end fashion from 1995

9780170400336

Design features

- Softer, more draping fabrics
- Eclectic styling
- Influenced by a broader range of ethnic clothing styles and details
- More casual styling

Designers

- Dolce and Gabbana
- Jean Paul Gaultier
- John Galliano
- Issey Miyake
- Gianni Versace
- Calvin Klein
- Giorgio Armani
- Vivienne Westwood
- Alexander McQueen
- Stella McCartney
- Donna Karan (DKNY)
- Tommy Hilfiger

There are a number of costume institutes connected to museums that hold a large collection of clothing through many periods and provide great digital resources. Follow the links at http://nelsonpdtvce.nelsonnet.com.au.

AUSTRALIAN FASHION DESIGN

PROFILE: HALL LUDLOW

Hall Ludlow (1919–2003) is regarded as Australia's first couturier. After a difficult start to life in an orphanage in New Zealand and then through jobs that he hated, Ludlow started making clothes for friends. Although he had no training, apart from his observations of the sewing of his orphanage matron, he would drape and cut the fabric straight onto a dressmaker's dummy. In 1945 he landed his first designing job, at Julia Yates' 'Ladies' Paradise' salon in Auckland.

Ludlow moved first to Sydney and then to Melbourne, and opened his own salon at the 'Paris end' of Collins Street in 1948. He dressed most of the society women at that time and won the prestigious Australian Gown of the Year award seven times. He relished the glamour and extravagance of fashions in the 1950s.

HALL LUDLOW, Melbourne (manufacturer, designer) Evening Ensemble 1955; linen, silk; (a) 152.0 cm (centre back) 32.0 cm (waist, flat) (dress) (b) 89.0 x 269.0 cm (wrap); National Gallery of Victoria, Melbourne; Gift of Mary Newsome, 1995; 1995.520.a–b

An ensemble gown, by Hall Ludlow

Ludlow was asked to design a collection for the Australian Wool Board that was shown in Europe in 1960. It was seen as very advanced, as over a third of the collection consisted of pants of various forms. But he never embraced the miniskirts of the 1960s – under no circumstances would he allow his skirts to be shorter than 5 centimetres below the knee.

In the 1960s, Ludlow moved briefly to Sydney, and then established himself in Hong Kong until the late 1970s. While there, he also designed for large stores in the USA, and his gowns were worn by stars such as Judy Garland and Liza Minnelli. In 1979, he returned to Sydney, and was still designing special-occasion clothing for select clients well into his 70s.

Ludlow's great design skill was recognised in a number of retrospective exhibitions of his work that were held in Melbourne in the mid-1990s.

9780170400336

Influences

- Balenciaga, Dior and Givenchy
- Hated the clothing of the 1960s and 1970s, which he called 'a non-fashion era'

Design features

- Extravagant use of luxurious fabrics
- Draping and moulding over the body
- Elegant, strong, clean lines and silhouettes
- Beautifully finished garments, with very fine stitching

Creating a riot

In Auckland in the late 1940s, the police had to be called to disperse a crowd that gathered at windows where Hall Ludlow gowns were displayed.

PROFILE: JENNY KEE AND LINDA JACKSON

Both Jenny Kee and Linda Jackson use Australian motifs in a bold and striking way.

Jenny tapped into a growing nationalistic undercurrent in Australia in the 1970s and 80s (spurred on by Australia's America's Cup win in 1983 and bicentennial celebrations in 1988), and used images such as Australian animals, bird and flowers in simple – almost symbolic – shapes and strong colours. Seeing these designs now, they can seem something of a cliché, but at the time the images of koalas, the Sydney Opera House, Sturt's desert pea, etc., were fresh, bold and emblematic of our growing confidence in Australiana. Jenny and Linda were both inspired by the native environment, and Jenny also connected with Australian woollen history through her revival of hand-knitting.

Linda's painted and printed fabrics and fashion reflect the colours, textures and patterns of the environment, whether the inspiration is the bright plumage of a bird or the earthy richness of the soil.

FLAMINGO PARK, Sydney (manufactureer); Jenny KEE (designer), Jan AYRES (knitter); Blinky, 1977; wool, handknit; 70.0 cm (centre back) 48.0 cm (sleeve length); National Gallery of Victoria, Melbourne; Purchased, 1986; CT25-1985; © Jenny Kee; Reproduced with permission Jenny Kee

Blinky jumper, by Jenny Kee

National Gallery of Victoria/© Linda Jackson/Licensed by Viscopy, 2017

Black Opal Lightning Ridge poncho, by Linda Jackson

Influences

- Australian environment, and native flora and fauna

9780170400336

Design features

- Strong, bold colours – often primary/brights, but also earthy browns, ochres, reds and black
- Simple clothing shapes – images and the Australian connection are predominant
- Simplified animal, bird and flower shapes used as patterns – sometimes abstracted
- Many patterns were later used on bed linen, homewares, etc.

PROFILE: JENNY BANNISTER

Jenny Bannister has worked in the fashion industry for more than 30 years. She and her sister, Wendy (once a model, now a fashion stylist), moved in the early 1970s from Mildura to Melbourne, where Jenny trained at Emily MacPherson College (now RMIT). While she was studying, her teachers recommended that she use her creative talents as a theatre costume designer, as they couldn't foresee her success in the sometimes conservative Melbourne fashion industry.

Jenny began working in a number of small boutiques, and then started her own label and worked on consignment for Clarence Chai. She sold many of her designs over the following years to retailers Australia-wide. She didn't try to fit in with the current styles and was frustrated by the Australian copying of trends from European design houses. In the 1980s, she was one of the founders of the Fashion Design Council, which fostered young and creative designers, such as Martin Grant. Its annual fashion parades were innovative and exciting.

Many of Jenny's designs have found their way into art galleries and museums, e.g. her wedding dress – a green snakeskin gown (1985) – was purchased by the Australian National Gallery, Canberra. In 2005, Jenny was immortalised as a 'fashion legend' on an Australian postage stamp.

Jenny's designs are strong, dramatic and theatrical, using unusual materials, textures, contrasts and processes. She recognises a distinction in her work between the more practical but still dramatic clothing for retail and her 'body sculptures' or 'art clothes'. She has been involved in a number of exhibitions, showing her more creative designs. In 1997, she opened her own boutique selling evening wear and special event clothing, and she continues to design for her annual show at the Melbourne Fashion Festival.

JENNY BANNISTER, Melbourne (manufacturer); Jenny BANNISTER (designer); Mermaid, 1978; plastic, nylon, shells, silk; 86.0 cm (centre front) 37.0 cm (waist, flat); National Gallery of Victoria, Melbourne; Gift of the artist, 1998; 1998.184. © Jenny Bannister

JENNY BANNISTER, Melbourne (fashion house); Jenny BANNISTER (designer); Je suis mod deluxe, 1980; plastic, cotton, metal, found objects; 81.0 cm (centre back) 44.0 cm (waist, flat); National Gallery of Victoria, Melbourne; Gift of the artist, 1998; 1998.192. © Jenny Bannister

Mermaid dress (left) and *Je Suis Mod Deluxe* dress (right), by Jenny Bannister

9780170400336

Influences

- Cultural and artistic trends
- Not influenced by current fashion trends or overseas designers

Design features

- Lots of contrast: in fabric type and quality, textures and finishes, patterns
- Use of unusual materials – e.g. plastic, leather, found objects (her *Je Suis Mod Deluxe* dress has records, film reels, a plastic doll and Lego pieces attached to it)
- Drama – strong, bold colours, metallics, etc.

PROFILE: MARTIN GRANT

Martin Grant revealed an interest in – and a prodigious talent for – fashion design from a very early age. His kindergarten drawings of women in glamorous ball gowns, and tales of Martin styling his sisters' dress-up plays, indicate his early eye for clothing and style. This talent was encouraged and developed by his grandmother, a skilled dressmaker, who taught Martin many of the skills he later applied to his work.

As a teenager, Martin taught himself pattern making, and after leaving school at 15, he worked for Desbina Collins, who recognised his talent and gave him room to develop his own designs within her studio. He also flourished within the artistic environment of the Fashion Design Council, which was based in the Stallbridge Chambers (Little Collins Street, Melbourne).

By the age of 18, Martin had established his own label, and was designing two collections for men and women each year. However, even though he was named the Cointreau Young Designer of the year in 1988, at the age of 22, he decided to change direction and studied sculpture at the Victorian College of the Arts. He was able to connect the concepts of sculpture and clothing design, and continued designing in a limited way during his studies.

After completing his course, Martin moved to London, where he worked for Koji Tatsuno and developed his skills in refined tailoring. He took a risk by moving to Paris in the early 1990s – he knew no French, but developed strong connections with other designers working there. He started working from an old Montmartre hospital that was a recognised squat for artists and designers (similar

National Gallery of Victoria/Martin Grant, Paris, Napoleon coat

Napoleon coat, by Martin Grant

MARTIN GRANT, Paris (fashion house); MARTIN GRANT (designer); Diamond pleat corset dress; wool, silk, acetate; 2006 spring-summer; 90.0 cm (centre back); 34.0 cm (waist, flat); National Gallery of Victoria, Melbourne; Purchased NGV Foundation, 2007 (2007.10); © Martin Grant

Diamond pleat dress, by Martin Grant

9780170400336

in feel to the Stallbridge Chambers) and grew a client list through word of mouth. Martin then moved to the Marais district and his international recognition gradually increased.

Martin is known for his finely structured garments, which show detailed tailoring and an understanding of the human form. His colours are usually understated and he rarely uses patterned fabric, but he enjoys the textures and drape of quality fabrics. Martin uses traditional garment forms, but subtly changes them through the cut and shape of sleeves, collars, cuffs, bust shaping, pockets, pleating, necklines, etc. His involvement in a number of installation exhibitions shows his continued interest in sculpture and its connection with fashion design.

Influences

- Classic European designers – Dior, Balenciaga
- His grandmother, Nancy Grant
- Historical clothing details and shapes
- His time working for designers Desbina Collins (Melbourne) and Koji Tatsuno (London), and his collaboration with other designers and artists

Design features

- Simple, elegant lines and shapes, but highly structured garments
- Impeccable tailoring – shapes that mould to the body through pattern shaping
- Common use of topstitching to accentuate garment structure
- Luxurious, high-quality fabrics – frequent use of wool for dresses and coats
- Use of traditional garment types (e.g. shirt dress, short coat) with a new approach
- Restricted colour palette – often neutral, classic or subdued colours, sometimes highlighted by a strong, bright colour.

A link to Martin Grant's website has been provided at http://nelsonpdtvce.nelsonnet.com.au.

PROFILE: AKIRA ISOGAWA

For his first 21 years, Akira Isogawa lived in Kyoto, Japan, and absorbed many of the cultural aspects of this traditional city. After a year of travel, he settled in Sydney and felt invigorated by the freedom he experienced in Australia. His enjoyment in altering clothes found in op shops revealed an interest in textiles and clothing design, and he began studying fashion design at the East Sydney Tech (now known as the Fashion Design Studio, located at Ultimo TAFE).

In 1993, Akira opened his first shop in Woollahra, Sydney, but it was his 1996–97 collection shown at Australian Fashion Week that created national and international interest in his work. Overseas fashion stores started purchasing Akira's clothing, and his Paris shows, which had started in 1991, strengthened his international reputation.

Akira's early clothing shows a clear connection with his Japanese past, but more recent work

AKIRA, Sydney (fashion house); Akira ISOGAWA (designer); Etheric zest outfit 2000 (autumn-winter); wool, cashmere, silk, glass beads, plastic sequins; (a) 38.0 cm (centre back) 45.0 cm (sleeve length) (jacket) (b) 56.0 cm (centre back) 61.0 cm (sleeve length) (jumper) (c) 83.5 cm (centre back) 57.0 cm (waist, flat) (overskirt) (d) 107.0 cm (centre back) 35.0 cm (waist, flat) (skirt); National Gallery of Victoria, Melbourne; Kaiser Bequest, 2000; 2000.101.a-d; © Courtesy of the artist

Etheric Zest outfit, by Akira Isogawa

9780170400336

reflects broader sources of inspiration. His clothing is acclaimed for being very person-focused – it is comfortable to wear and works with the shape of the body. He uses interesting fabrics – some are delicate, some are intricately printed or painted, and some are textured; and he sometimes contrasts different textures and weights. He also uses interesting processes to create the forms of his clothing, e.g. pleating, folding, dramatically draping, layering and gathering.

Akira is creative and inventive in his designs, and doesn't follow the trends set in colour, fabric and clothing shape. His work has a strong connection with the visual and performing arts. His clothing has been exhibited in the Museum of Contemporary Art, the Powerhouse Museum and the National Gallery of Victoria. He has designed the costumes for at least five Sydney Dance Company performances and has worked with the Australian Chamber Orchestra to design their onstage clothing.

Influences

- Aspects of Japanese culture and arts – kimono shapes, folding, layering, fabrics, origami
- Artwork from a range of cultures and countries
- Collaboration with other designers, artists and art forms

National Gallery of Victoria/Akira Isogawa Installation from Printemps-Ete' exhibition

An installation photograph from Akira Isogawa's Printemps Été exhibition

Design features

- Folded and draped fabric to form around the body, or to give texture and pattern
- Use of natural fibres – silk, linen, wool, etc.
- Layering of fabrics and garment pieces
- Ethereal is a word often used for Akira's designs – an impression created by the choice of floaty fabrics and fabrics that drape and flow dramatically
- Highlighted use of delicate or dramatic fabric printing and painting, reminiscent of kimono fabric

Search Akira Isogawa's website for his latest clothing designs. A link has been provided at http://nelsonpdtvce.nelsonnet.com.au.

PROFILE: COLLETTE DINNIGAN

Collette Dinnigan had a nomadic childhood – born in South Africa, travelling across the seas with her family as a child, and settling in New Zealand, where she later studied fashion and textiles. After a shift to Australia and an early career in the Australian Broadcasting Corporation costume department, Collette started her independent fashion business in the early 1990s, initially with a line of lingerie (which started her strong connection with lace, a recurring material of choice through her work). She opened a number of boutiques in Sydney and Melbourne, and later in London, and her designs were picked up by large department stores in Australia and New Zealand, New York, London and Hong Kong.

Holly Ward

Dinnigan (third from left) surrounded by models wearing her designs

Collette's career is a story of hard work and consistent performance over many years. She is the only Australian designer to be invited by the Chambre Syndicale du Prêt-à-Porter des Couturiers et des Créateurs de Mode trade association to show in its Paris ready-to-wear schedule. She later became a member of the association's organising committee. Collette has also collaborated with many businesses and creative organisations. In 2003, she worked with the Australian Ballet and the National Gallery of Victoria on a garment for their 'Tutu' exhibition, and later worked with Australian Ballet again, with Target, to design a range of ballet-inspired outfits for children. Collette has had an ongoing connection with the Australian Wool Board, and has been the Wool Ambassador for the Australian Wool Institute.

In later years, Collette diversified her creative work, developing diffusion ranges for Target (lingerie) and Aldi (children's wear), and venturing into sunglasses, linen and interior design.

Collette has received a broad range of awards – from Designer of the Year and Innovator of the Year at the Australian Fashion Awards in 1995 to, more recently, being awarded the fifth Australian Fashion Laureate Award by the New South Wales Government and being inducted into Massey University's Creative Arts Hall of Fame. A large-scale exhibition of her work, Collette Dinnigan: Unlaced, was mounted in the Powerhouse Museum, Sydney, in 2015, and her lingerie was selected for a Victoria and Albert Museum exhibition, Undressed: A Brief History of Underwear, in 2016–17.

In 2013, Collette changed her business model, ceasing her regular fashion shows in Paris after 20 years, and closing her boutique stores. She moved to Rome, spending more time with her young family. She is still involved in the fashion industry and has continued designing for children's wear and interior design.

Lace features heavily in Collette's work, and was initially her work's most recognisable feature. However, Collette's work plays with aspects of transparency and light, layering fabrics such as lace and tulle over other fabrics. She also works with contrasting textures, highly reflective fabrics next to softer textures. When she works with patterned fabrics, their fine detail connects with her interest in lace. Collette's technical skill is shown in the subtle tailoring and draping of fabric to fit to the body with clean lines and shapes.

Design influences

- Vintage clothing and antiques – particularly fabric weave, hand embroideries and details in the garment construction
- Different cultures, the arts, museums and textiles

Design features

- Contrasting textures – lace, tulle, satin, chiffon, mixed with wools, jerseys and suitings
- Focus on materials – careful use of draping, transparency and reflective qualities
- Attention to detail, particularly in the use of patterning and lacework, and garment shaping
- Clean, modern, feminine lines and shapes
- Adult fashion – frequent use of black, white, cream and silver with hits of strong colour
- Children's wear – bright colours, use of mixed prints and patterns

Look at Collette Dinnigan's website for more images and information. A link to the website has been provided at http://nelsonpdtvce.nelsonnet.com.au.

PROFILE: DINOSAUR DESIGNS

Louise Olsen and Stephen Ormandy met on their first day of studying at Sydney's City Art Institute (now known as UNSW Art and Design) in the mid-1980s. Two years later, together with Liane Rossler, they started making jewellery from Fimo modelling clay and selling it in Sydney's Paddington Markets, then began experimenting with resin. Within a few years, their work had been noticed by *Vogue*, picked up by a number of prominent stores in Australia and London, and they started exporting to New Zealand, the USA and Germany. Dinosaur Designs was also invited to exhibit at the Victoria and Albert Museum in London. The company opened its first retail store in Sydney in 1989, and now has 10 stores in Sydney, Melbourne, Brisbane, London and New York, as well as retailing online and through other retailers. In 2010, Louise and Stephen became Dinosaur Designs' creative directors, while Liane moved on to other projects (while still retaining a one-third share of the company). Louise and Stephen are actively pursuing their own art careers, as they intended when they formed Dinosaur Designs, both as individual painters creating solo shows, and producing collections of sculptures, which are shown around the world, under the name Olsen Ormandy.

Dinosaur Designs

Stephen Ormandy and Louise Olsen of Dinosaur Designs

9780170400336

Alamy Stock Photo/Bill Bachman

Dinosaur Designs Bart Celestino jewellery/bangles in rock, stone, wishbone, lighthorn

Dinosaur Designs

Dinosaur Designs Louise Olsen–designed side table

Designing and making their work initially involves sketches and clay modelling, then a resin prototype is created and the design fine-tuned. A cast is then made for production, pieces are moulded and then hand sanded and finished in their Sydney studio. Metal and textiles pieces are designed and prototyped in-house, then manufactured by skilled craftspeople overseas.

Dinosaur Designs has worked collaboratively with numerous fashion designers, companies and cultural organisations, and their work has been shown in many exhibitions in museums in Australia, New York, London and Milan. Their jewellery has been worn by many fashion icons, and the company has a strong international profile.

Dinosaur Designs is a company that is aptly named – their work seems to be a modern reimagining of early human adornment, or something worn smooth in a river. Even though each collection is creatively different in focus, Dinosaur Designs pieces have a consistency of style and approach. Most are organic in shape, with some contrasting hard lines and edges, and the jewellery ranges from the bold to the delicate, more recently combining precious metals with resin in a single piece. Materials play with contrast – with levels of translucency and opacity; with neutral earthy tones and strong colours; with soft matt, glassily shiny and bright reflective surfaces and the 'hand-felt' nature of each design, which is then rendered in a modern material – resin. Dinosaur Designs has broadened its original focus on jewellery and homewares to now include furniture pieces. These pieces continue to focus on the use of resins, organic forms and colour choices ranging from bold and bright to earthy and neutral.

Design influences

- Nature and art

Design features

- Use of resin
- Organic forms
- Playing with translucent and opaque resin, either through marbling or in solid form
- Contrasting natural and neutral colours with brights and metallics
- Soft, handcrafted feel
- Consistency across all types of design work

Dinosaur Designs shows a commitment to corporate and environmental responsibility. Check out the website for the practical strategies they have implemented. A link has been provided at http://nelsonpdtvce.nelsonnet.com.au.

PROFILE: ROMANCE WAS BORN

The Romance Was Born label was launched in 2005, led by the creative imaginings of Anna Plunkett and Luke Sales. Luke and Anna recognised an artistic connection while studying at the Fashion Design Studio (Sydney). Both were from regional Australian backgrounds and were taught crafts (sewing, crocheting, etc.) by family members; both have a fondness for the Country Women's Association – for creating, crafting and making do. When travelling overseas after their studies, Anna and Luke were offered internships in John Galliano's Paris fashion house, but turned them down to follow their own path of travel and cultural and aesthetic discovery.

Luke and Anna work on the border between fashion and art, and have partnered with a diverse range of artists when developing their collections. Romance Was Born collaborated with the National Gallery of Victoria in 2014 to create the interactive and immersive exhibition Express Yourself: Romance Was Born for Kids. There is a feeling of childlike wonder and play in their work – in the use of fabrics, colour and pattern, and in the theatrical make-up and accessories used in runway shows. These shows tell a visual story, and often make strong connections to children's literature, with references to *Snugglepot and Cuddlepie* by May Gibbs, *Alice in Wonderland* and *Little Lord Fauntleroy*. Underneath the dramatic extravagances of their shows, their clothing is very wearable, draping over, structured around and working with the female form.

Daniel Boud

Anna Plunkett and Luke Sales, the creative core of Romance Was Born

Daniel Boud

From the Mushroom Magic collection, 2013

Design influences

- Collaborative work with artists
- Stories and children's literature
- Crafting traditions

Design features

- Whimsical and fantasy-like
- Strong narrative and aesthetic for each collection
- Explosive use of colour – bright jewel colours, strong contrasts

9780170400336

Getty Images/Brendon Thorne

From the Mercedes-Benz Fashion Week, 2016

- Use of fabric pattern, often overlaying and juxtaposing different patterns
- Exploration of texture – translucent, reflective/shiny, encrusted decoration, soft feathering and flounces
- Connection to rich handcrafted work – embroidery, beading and sequins, appliqué, crochet, paper folding
- Floaty, draped and shaped feminine forms

Find out more about Romance Was Born from their website. A link has been provided at http://nelsonpdtvce.nelsonnet.com.au.

AUSTRALIAN INDIGENOUS TEXTILES

Fabric printing and painting

Although textile and fibre arts have had a traditional place in Aboriginal and Torres Strait Islander culture for many generations, printed and painted textile work is only a recent expression of Indigenous Australian visual language and storytelling. Professional artists and craftspeople collaborated with Indigenous Australian communities in the 1970s and 80s to develop skills in these new textile print methods, and since that time many communities have used **batik** and screen printing, and applied their images to artworks for exhibition or to fabric for everyday or commercial use.

batik
a method of decoration using wax resist and dye

The use of batik in Indigenous Australian communities started with the Pitjantjatjara people of Ernabella, South Australia. Their fabric designs had no 'story' and were separate to images made for the **Dreaming**, but the decorative designs used shapes and colours that reflected the land, as well as those used in cave and body painting. The Ernabella women used fine cloth, cotton and silk as a base for their designs, which were usually detailed and very technically proficient.

Dreaming
an Indigenous Australian understanding of the land, culture and 'story'

Batik spread to other Pitjantjatjara communities, and to Utopia in the Northern Territory, where Anmatyerr and Alyawarr women developed a very free and expressive use of the form in the early days. Batik was also introduced to the Walpiri men and women at Yuendumu (Northern Territory) through their connection to Utopia. Their work is based on the use of symbols and signs that express aspects of their land and stories.

BERYL NAPANGARDI ROBERTSON, Ngalyipi manu karnta Jukurrpa (Snake vine and women's Dreaming) 1986, batik on cotton; 224.0 x 88.0 cm; National Gallery of Victoria, Melbourne; Presented through The Art Foundation of Victoria by Peter and Theodora Toyne, Members 1995; 1995.713. ©Yundumu Aboriginal Artists/Beryl Napangardi Robertson/Licensed by Viscopy 2017

A Yuendumu batik, showing kangaroo seeds and women's dreaming

9780170400336

During the late 1980s and 90s, the use of batik spread broadly to northern Queensland, and to Arnhem Land and Bathurst Island in the Northern Territory. Silk painting also developed during this time, although this was mainly focused on the Eastern Arrernte artists at Ltyentye Apurte (the mission of Saint Teresa) and the Daly River artists at the Merrepen Arts Centre (Northern Territory).

Tiwi Designs of Bathurst Island is probably the most well-known Indigenous Australian screen printing workshop. The screen printing work is predominantly done by the men in the community, and the images were originally based on those used earlier for woodblock printing. Designs were gradually adapted to the techniques of screen printing and repeat patterns. Designers effectively used lines, dots and hatched patterns to form motifs of birds, animals, totems and their recognisable pukumani (burial) poles. The 13-metre length of their printing table limited the print run quantity of their fabrics, which made Tiwi Designs exclusive.

EMILY KAM KNGWARRAY, Shirt, 1979, batik on cotton; 68.3 cm (centre back) 55.5 (sleeve length); National Gallery of Victoria, Melbourne; Gift of Avril Green, 1999. © Emily Kame Kngwarreye/Licensed by Viscopy, 2017

A shirt using fabric designed by Emily Kame Kngwarreye

The development of Bima Wear ran parallel to that of Tiwi Designs. Originally set up as a clothing workshop for the Bathurst Island community, Bima Wear gradually developed into a printing and clothing fashion business run by Tiwi women. Their success encouraged other Indigenous Australian communities to set up fashion design labels.

TIWI DESIGNS (workshop); BEDE TUNGUTALUM (designer); Tiwi bird design, 1988, screenprintd cotton; 72.1 x 50.6 cm; National Gallery of Victoria, Melbourne; Presented by Tiwi Designs Aboriginal Corporation, 1996; 1996.783 /© Tiwi Designs, Bede Tungutalum/Courtesy of Tiwi Designs. Licensed through Viscopy, 2017

A bird screen print, by Tiwi Designs artist Bede Tungutalum

9780170400336

Getty Images/AFP Photo/William West

Aboriginal artists Treahna Hamm (left), Lee Darroch (centre) and Vicki Couzens (right) wear traditional decorated possum-skin cloaks, made for an exhibition at Melbourne Museum's Aboriginal Cultural Centre, 2006

Possum-skin cloaks

In Victoria and New South Wales, the Indigenous Australian people have a rich history of making and using possum-skin cloaks – both as a practical garment and as a way of telling their stories. The cloaks were made from joined rectangles of tanned possum skins that had images or patterns cut into the inside surface (which also helped to make the skin flexible). Before the mid-19th century, these cloaks were used to keep people warm, to carry their young, as a drum stretched over their knees, and as a wrapping when they died.

In 1999, Gunditjmara women Vicki and Debra Couzens and Yorta Yorta women Lee Darroch and Treahna Hamm were moved by two possum-skin cloaks in Melbourne Museum's collection – the only remaining cloaks in Australia. To make new cloaks, they set about learning the old skills and developing new ones. Sourcing the possum skins was a problem, as these animals are protected in Australia, so they shipped the skins from New Zealand, where possums have become a pest. These were tanned differently, and were very soft and pliable, so the old cutting method for creating designs was not appropriate. Instead, they used pyrographic equipment to scorch lines onto the inside surface of the cloaks.

The artists reproduced the original designs on the cloaks – the lines and shapes that symbolised their Country and Koorie life, the rivers, lakes, eel traps, meeting places, etc. It was through the experience of making the cloaks, and discussions with their elders about the cloaks, that the women made connections with the 'Old Ones', their ancestors, and grew to recognise and understand the symbols used on the cloaks.

FURNITURE DESIGN

This section is a brief introduction to furniture design over the last 150 years. It will help you to compare and perhaps make some initial decisions about the stylistic direction that could be a unifying aspect of your design work. These areas can be explored in more detail through your research.

The styles discussed in this section are not 'boxes' into which designers slot neatly; they are loose connections of people with common approaches. Sometimes there are ideas and philosophies that flow through many styles, and designers who overlap styles or hover around the fringes, or change and experiment with different approaches.

Shaker furniture (late 19th century)

The Shakers were an American religious community whose beliefs had a strong effect on the lifestyle of those involved, and influenced the design and production of their furniture. Shaker communities valued handcrafting skills highly, and often made furniture without nails and hardware. Reflecting their philosophically simple and functional approach to design, they developed a system of hanging furniture on a high rail, so that rooms could serve multiple purposes and be easy to clean.

Design features

- Simplicity and purity of form, minimalist styling
- Limited or no decoration
- Shape of furniture completely determined by function (the 'form follows function' philosophy that is followed in most modernist furniture styles)
- Pure use of materials (natural colours, minimal finish)

Alamy Stock Photo/David Lyons

The simple, pure shapes and forms of Shaker furniture

East meets West: Japanese style

The opening of Japan to the West in the 1870s started a fascination with Japanese art and culture. Japanese art, decorative style and wood-crafting techniques were influential in the development of western art and furniture in the late 19th century and early 20th century.

Design features

- Simple, clean, geometric shapes – minimal, uncluttered
- Dark timber colour (accentuating the shape)
- Highly crafted and unique joinery techniques
- Some metal elements (functional and decorative)

Designers

- Edward William Godwin

Getty Images/De Agostini/ A.C. Cooper

The *Godwin* sideboard, by Edward William Godwin, has clear Japanese features

9780170400336

Alamy Stock Photo/V&A Images

The *Argyle* chair, by Charles Rennie Mackintosh

Arts and Crafts movement

The Arts and Crafts movement was initiated by the artist and writer William Morris in the late 19th century. Morris wanted to improve the circumstances of the lower classes – to make good design and fine craftsmanship accessible to all, not just the privileged. There was a strong focus on traditional handcrafting skills, with artisans working in guilds. The aim was for all things to be integrated and thoughtfully designed – buildings, lighting, wallpaper, furniture, kitchenware, etc.

Arts and Crafts objects often included decorative features, and each of the key practitioners had their own decorative style – for example:

- Morris – realistic, based on natural forms
- Mackintosh – more stylised and exaggerated
- Lloyd Wright – abstracted decorations.

In the later American version of the Arts and Crafts movement (from around 1900 to the 1920s, sometimes called 'mission' style or 'craftsman' furniture and design), there was still a strong focus on finely crafted skills, and the design of the 'whole' house and all its contents, including details such as rugs and lead-lighting.

Design features

- Handcrafted
- Design of the whole living environment
- Decorative details – originally from nature, but becoming more abstracted
- Predominant use of wood, leather, fabrics, glass, hand-wrought metals

Designers

- William Morris
- Charles Rennie Mackintosh (also aligned with Art Nouveau)
- Gustav Stickley
- Frank Lloyd Wright (also aligned with Art Deco and the Prairie School of Architecture in the USA)
- Walter Burley and Marion Mahony Griffin (USA/Australia; also aligned with Art Deco)

Art Nouveau

Art Nouveau is an architectural, art and design movement that developed just before the start of the 20th century (it has other names in different countries, e.g. the more restrained German form is called 'Jugendstil'). The style gained widespread recognition at the 1900 Paris Exposition.

Art Nouveau was a reaction against the heavy forms of the Victorian era, and was partly influenced by the styles of Japanese woodcuts. One aim was for 'art to be part of everyday life'; however, this was only for those who could afford it (it was mostly very expensive, individually crafted work).

Design features

- Highly decorative, use of dynamic lines and elongated shapes
- Use of organic, exaggerated curved forms (including tree, plant and flower forms) – sinuous, elegant, usually freeform and not symmetrical
- The style was applied to many forms, e.g. architecture, glass, jewellery, furniture, lighting, fashion, eating implements
- Highly crafted forms, involving new industrial methods of using metal

Getty Images/DeAgostini

Art Nouveau-style three-legged table, 1902, by Louis Majorelle

Designers

- Louis Majorelle
- Georges de Feure
- Hector Guimard (who designed the entrances to the Paris Metro)
- Eugène Gaillard
- Henry van de Velde
- Antoni Gaudí

Art Deco (1920s)

The Art Deco style has a range of influences, including Cubist, Japanese, Chinese, African and Egyptian art and artefacts, the philosophies of the Bauhaus, the 'machine age' and a reaction against the highly ornate Art Nouveau. There were two main manifestations – in France (escapist luxury in a postwar and Depression environment), and the Streamline style in the Americas (1930s).

Streamline

Streamline uses sleek curves, a modern industrial or manufactured look, and simple geometric decoration. It often refers to design features of transportation design in the 1930s and 40s, and was prevalent in American commercial product design during that period.

Shutterstock.com/DutchScenery

Art Deco clock

Design features of Art Deco design

- Sleek, geometric shapes
- Simplified forms
- Expensive material and techniques – modern, exotic, luxurious materials and finishes, use of chrome, veneers and lacquering

9780170400336

Designers

- Otto Wagner
- Koloman Moser
- Josef Hoffmann
- William Van Alen (designer of the Chrysler Building)
- Jacques-Émile Ruhlmann
- Paul Follot
- Jean Després
- Donald Deskey (interiors of the Rockefeller Center)

International Modernism

International Modernism – sometimes called the 'International Style' – is a broad term that is often used to encompass many of the early to mid-20th-century styles and designers. Its main features include the use of industrial materials and processes, a reaction against decorative styles, a move to purity of form and the importance of function and ergonomics, and the accessibility of design for all.

Getty Images/Eric Piermont/AFP

The Irish designer and architect Eileen Gray's *Bibendum* chair, *Transat* chair and *E1027* adjustable table

Design features

- Clean, geometric shapes and lines
- Frequent use of tubular steel

Designers

- Le Corbusier
- Eileen Gray
- Russell Wright
- Can also include the designers of the De Stijl and Bauhaus movements

De Stijl

De Stijl was a Dutch movement of 1917–31, founded by architect and artist Theo van Doesburg. The movement originally outlined a new aesthetic for art, but spread to town planning, applied arts and philosophy. Piet Mondrian is one of the most well-known De Stijl artists.

Design features

- Searching for simplicity and harmony in abstraction, reducing to purest form
- Use of straight lines and rectangular shapes (later included diagonal lines)
- Limited range of colours (red, yellow, blue, black and white)
- No surface decoration

Designers

- Gerrit Rietveld

Shutterstock.com/Marko Bradic

Red Blue Chair, by Gerrit Rietveld

Bauhaus

Bauhaus was an art, design and architecture school in Germany during the time between the two World Wars. The school had a strong social philosophy, but was closed in the mid-1930s as the political environment in Germany became more difficult. Bauhaus was very influential on the teaching of design internationally, as many of the major Bauhaus teachers moved elsewhere in Europe or to the USA in the 1930s. Bauhaus designers explored the use of industrial processes to make objects cheaper and easier to produce in larger numbers, and to reduce material bulk while retaining functional strength.

Shutterstock.com/fusebulb

Barcelona chair and ottoman, designed by Ludwig Mies van der Rohe

Design features

- Aesthetic forms coming from the harmony of simple geometric shapes and forms
- Emphasis on the function of objects
- Use of industrial methods and materials, increased use of metal
- Products designed for mass production
- Design for the **synthesis** of architecture and product design: the totality of the building and its contents

synthesis
the merging of forms and ideas across different design fields

Designers

- Wassily Kandinsky (artist)
- Ludwig Mies van der Rohe
- Marcel Breuer
- Walter Gropius

9780170400336

Shutterstock.com/Thomas Hernandez

The *Paimio* chair, designed by Finnish architect/designer Alvar Aalto (1932), has a bent, laminated birch frame and a bent plywood seat

Scandinavian design

A recognisable style developed in the Scandinavian countries of Denmark, Sweden, Norway and Finland during the mid-1940s and beyond. This style had a focus on good-quality design for the masses, a clean aesthetic (simple flowing lines and shapes) and sympathetic use of materials (natural finishes and fabrics). The style was seen in the design of furniture and a broad range of homewares and electronic products. Out of this environment grew a large number of globally successful industrial/manufacturing companies.

Design features

- Simple shapes and forms
- Softening use of curves, and round or cylindrical forms – frequent use of bent laminated frames
- Frequent use of pale-coloured timber in furniture
- Handcrafted and industrial manufacturing processes

Designers

- Arne Jacobsen
- Alvar Aalto – the Artek furniture company
- Verner Panton
- Hans Wegner
- Companies such as Ericsson, Nokia, IKEA, Bang & Olufsen, Georg Jensen, Electrolux

Organic Design uses simple natural forms, predominantly made from wood, with a focus on designing holistically and for human use

Biomorphism attempts to morph artistic design elements into naturally occurring shapes reminiscent of nature

Pop design typically 1950s and 1960s style with fun, simple geometric and futuristic shapes, often made from plastics

Alamy Stock Photo/Pablo Scapinachis

Lounge chair *670* and ottoman *671* by Charles and Ray Eames

Mid-Century Modern (1950s and 60s)

This is a grouping of mainly American 'modernist' designers, who worked in the years after 1945 in an industrial and developing consumer environment. These designers applied **Organic Design** approaches that were later exaggerated in **Biomorphism**, and some moved into the **Pop design** culture of the 1960s and beyond.

Design features

- Use of modern industrial materials and processes, particularly the expanding use of plastic and formed-timber veneer

9780170400336

- Clean organic and geometric forms – particularly shapes that mimic the curving of the body
- Pure and sculptural – objects stripped down to basic form and function
- Strong, often vibrant colours

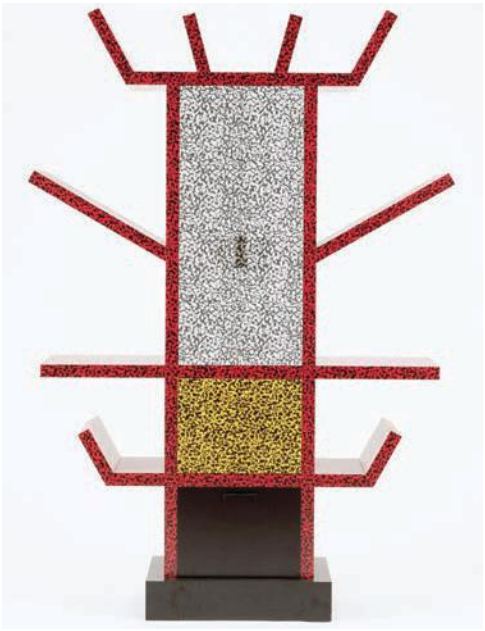
Designers

- Charles and Ray Eames
- Verner Panton
- Herman Miller (manufacturer)
- Eero Saarinen
- Isamu Noguchi
- Harry Bertoia

The International Furniture Fair of Milan (Salone Internazionale del Mobile) began in the 1960s. It is the leading furniture trade fair that showcases innovations (both technical/material and aesthetic developments) in furniture, lighting and homeware design, and often links designers with manufacturing companies.

Memphis

The Memphis group was a collection of Italian designers in the 1980s, headed by Ettore Sottsass, who reacted against the purity of form in modernist furniture. They created objects that were soon popular with young designers. Their work was designed for mass consumption (e.g. cheap materials, fashion-led design and not very durable), but their products were mainly collected by the wealthy.



Casablanca sideboard, by Ettore Sottsass

Casablanca Sideboard, designed, 1981 (plastic laminate & wood), Sottsass II, Ettore (1917-2007) / Philadelphia Museum of Art, Pennsylvania, PA, USA / Gift of Collab: the Group for Modern and Contemporary / Bridgeman Images

Design features

- Highly coloured, textured and patterned
- Sculptural designs
- Function and ergonomics secondary to style and aesthetics
- Playful – often not practical or comfortable to use
- Used mass-produced materials and processes, as well as handcrafting skills – whatever would turn their aesthetic ideas into reality
- Mixture of materials, use of lesser-quality materials

Designers

- Ettore Sottsass
- Michele De Lucchi
- Nathalie Du Pasquier
- Matteo Thun
- Alessandro Mendini

9780170400336

Wikimedia Commons/Sarah Fauconnier. CC BY SA 3.0 license

Frank Gehry's *Easy Edges* side chair

Postmodernism

This is another loose linking of designers who reinterpreted traditional forms with a twist, often with irony and humour, sometimes breaking the expectations of traditional and modernist forms. They used materials, textures and processes in unusual, and sometimes playful, ways to serve the aesthetic idea. Their designed objects were often sculptural in form as they deconstruct and reimagine the elemental components of furniture.

Designers

- Philippe Starck
- Alessi (a manufacturing company that commissions designers)
- Marc Newson
- Alessandro Mendini
- Frank Gehry
- Tom Dixon
- Karim Rashid
- Jasper Morrison
- Paolo Deganello
- Ron Arad
- Gaetano Pesce

For more information about designers and styles of furniture and product design, follow the links for this page at http://nelsonpdtvce.nelsonnet.com.au. online in the web resources for this chapter

Architect or designer?

Many significant designers of the 20th century were architects, who were moved to design the interiors and furniture to fit inside their architectural spaces in order to create a unified aesthetic vision (a total work of design, or a synthesised art form). Many of them tried to break down the separation between the design of a building and the design of objects used in the built space, with no difference in status between the two.

Philippe Starck

Philippe Starck, *W.W. Stool*

Other style terms for product design

Organic Design and Biomorphism

Organic Design uses simple organic forms, with a focus on designing holistically and for human use. It is a thread running through periods, styles and the work of many designers, from the integrated building, interior and furniture design work of Mackintosh and Lloyd Wright, through to the flowing curves of Alvar Aalto and Charles and Ray Eames. Furniture was predominantly made from wood, which was seen as a human, accessible material. In the 1960s and 70s, Organic Design ideas influenced the rise of Biomorphism ('morphing' of/from nature). The use of new manufacturing technologies and improvements in plastics allowed greater freedom of form and an exaggeration of natural shapes and lines. 'Biomimicry' is slightly different – it uses structures and solutions found in plants and animals, often found through scientific research, as the basis for design solutions.

Photography by Fabrice Gousset

The creature-like shape of Marc Newson's *Embryo* chair

Lillian van Daal

This 3D-printed chair by Lillian Van Daal is based on plant cell structure

Industrial Tech

From the 1970s onwards, designers of furniture and interiors within this style created an industrial feel by using industrial and utilitarian materials and fittings (ducting pipes, flooring rubber, corrugated iron and galvanised zinc, etc. – often salvaged). Bright primary colours frequently contrasted with these uncompromising materials.

AUSTRALIAN FURNITURE DESIGN

PROFILE: WALTER BURLEY GRIFFIN

Although not an Australian, Walter Burley Griffin (1876–1937) was very influential in the architectural and design fields while working in Australia in the early 20th century. Before coming to Australia, he worked for Frank Lloyd Wright from 1901 and developed his own architectural practice in Chicago from 1906. Architectural writing around this period – particularly about the William Emery house that he built in Elmhurst, Illinois, in 1903 – discusses his design of furniture and early electric light fittings.

9780170400336

Griffin and his wife, Marion Mahony Griffin, are well known for creating the layout of the national capital, Canberra, between 1913 and 1920, after winning an international design competition. During that time, he also designed the dining hall and college residences for Newman College, at the University of Melbourne. (In addition, he created a design for the chapel, but this was not used.)

Griffin designed many pieces of furniture and fittings to be used within the buildings he designed. These works were functional, but simple and elegant in shape and form. His most satisfying work in Australia was on the development of the Castlecrag Estate in Sydney between 1920 and 1935.

In 1935, Griffin left Australia to work on a number of commissions in Lucknow, India. He was even designing on his deathbed in hospital – sketching a bookrack so that he could read in bed. After his death, Marion Griffin returned to Chicago, where she continued to design, and also wrote four autobiographical volumes about their lives. She died in 1963.

Influences

- Prairie School of Architecture, Frank Lloyd Wright
- Japanese printmaking and traditional timber architecture
- South American pre-Columbian forms and decorative styles

Design features

- Materials are predominantly timber, fabric and leather (with metal and glass for light fittings, etc.)
- Simple, well-structured and balanced, uncluttered style

Café Australia table, by Walter Burley Griffin

National Gallery of Victoria, Walter Burley Griffin, Designer, H. Goldman Manufacturing Co. Melbourne Australia 1911-1927, Cafe Australia Table 1916.

The woman behind the man

Walter Burley Griffin's wife, Marion Mahony Griffin, was actively involved in developing his designs, particularly in their drafting. She had a very strong design background and was the second woman to graduate in architecture from the Massachusetts Institute of Technology. She was a talented employee in Frank Lloyd Wright's studio for 11 years before her marriage. She is known to have designed furniture, cutlery and linen for a number of the homes she designed.

Marion and Walter worked together to create their winning entry in the competition for the design of Canberra. Her creative work in this partnership is often overlooked, although more recently, a couple of books have been published that recognise her design work.

The *Lockheed Lounge*

This iconic piece of furniture, designed by Marc Newson, has been seen in many places – in the National Gallery of Victoria's furniture collection, in the National Gallery of South Australia, in Paramount (a hotel in New York) ... and on Madonna's 'Rain' video.

PROFILE: GRANT AND MARY FEATHERSTON

Grant Featherston started designing leadlight windows, but after World War II he moved into designing furniture. He developed ranges of furniture that included seating and cabinets, from the *Relaxation* chair of 1947 to the *Numero* suites in the 1970s. In the mid-1960s, with his second wife, Mary Featherston, he formed Featherston Design.

Grant wanted Australians to have access to the latest overseas developments in style and technology. He introduced the use of webbing as an external design feature, and is probably most

9780170400336

well known for his use of curved shapes that fit the body, made possible through his innovations in moulding plywood. His work shows his interest in simple, graceful, organic forms – he often played around with strips of paper, twisting, folding and curving. He searched for the simplest solution to a design problem and often found the genesis of an idea in natural forms.

Grant decided to stop designing furniture in the 1970s, due to his frustration with the conservative Australian furniture industry. However, he and Mary continued to design, focusing on creating environments for children's learning.

A National Gallery of Victoria retrospective of Featherston furniture in 1988 revived interest in their designs, and a Melbourne furniture manufacturer holds the patents and still produces some of the Featherston furniture designs. Grant died in 1995, but Mary is still working, focusing on design for learning.

Influences

- The Bauhaus for shapes and use of industrial materials
- New forms of technology in timber products, metal and plastics
- Scandinavian design

Design features

- Use of curves and simple organic shapes
- View chair design as the 'negative of the human body'
- Materials – curved plywood structure, tubular metal, finely curved timber, webbing, plastics (e.g. polystyrene, polyurethane) and fabric

National Gallery of Victoria, Grant Featherston designer, Relaxation chair 1947.

Relaxation chair, by Featherston Design

Featherston work showcased

In the late 1960s, Grant and Mary Featherston designed the glass and timber cabinets used by the National Gallery of Victoria to house much of its decorative arts collection.

PROFILE: MARC NEWSON

As a child, Marc Newson and his mother moved around a great deal, living in Sydney, Palm Cove (North Queensland) and London. Marc spent time travelling in Europe and this had a great influence on him, as did his early practical building experiences in his grandfather's workshop. After his mother's remarriage, he lived in South Korea, and was finally sent to boarding school back in Australia. It was there that his interest in creative things really came to the surface. He went on to study 3D art at the Sydney School of Arts, focusing on sculpture and jewellery, and also started making furniture. One of Marc's influences in his early design days was the contemporary art and design magazines that he read while working in a newsagency to support his income.

Through the 1980s, Marc struggled to find money for materials and had limited facilities. He always had a strong sense of shape, form and texture, and used whatever construction techniques he could manage and that suited his imagined forms. He would often apply processes from other manufacturing fields (e.g. boatbuilding and surfboard making) to his early furniture pieces.

9780170400336

Despite the purchase of his *Lockheed Lounge* chaise longue by the National Gallery of South Australia and his rising profile in Australia, Marc left for London, via Tokyo, in 1987. In Tokyo, he met the influential Teruo Kurosaki, the owner of the furniture company Idée, who bought some of his designs for production. It was through Kurosaki's support and the retainer he received as a designer for Idée that Marc was finally freed from financial struggle and was able to concentrate on design. Through Kurosaki, Marc also met many influential designers, including Philippe Starck.

From 1991, Marc's profile in Europe grew, through exhibitions and commissions from prominent manufacturing companies in lighting and furniture. He has designed watches, perfume bottles, retail and restaurant furniture and fittings, bicycles and cars. In 1999, he completed one of his dream commissions – fitting out the interior of a private aeroplane. More recently, he has created the interior spaces and furniture for the Qantas A380 Airbus.

Influences

- The absence of an established design culture in Australia (giving him freedom to explore, rather than be influenced)
- Beautifully designed sports cars and aircraft

Photography by Fabrice Gousset

The *Lockheed Lounge* chaise longue, by Marc Newson

Design features

- Strong sense of form and shape – organic and geometric curves
- Unconventional use of materials and processes
- Quirky interpretation of conventional forms
- Applies design sensibility to a wide range of products and projects

Australian design innovations

In many product design fields, Australian designers and inventors have developed innovative products now used across the world. They have shown creativity and an inventive use of materials, engineering and visual aesthetics. Their work is also shaped by the unique experience of living in our environment.

9780170400336

Innovative Australian companies, designers and product design

The following section is an extract from BlackBOX: Design and Innovation, written by Ian Wong. Further details can be downloaded via the BlackBOX app. Many aspects of design innovation and inventive products developed in Melbourne are explained in Ian Wong's research blog. A link to the blog is provided at http://nelsonpdtvce.nelsonnet.com.au.

10 L Esky, 2000
Catalyst Design

Esky® 10 Litre Classic Cooler

The portable cooler, or Esky, was created by a Sydney refrigeration company, Malleys. Nylex, Enco, Willow and Esky brands have been manufactured in Melbourne since the mid-1950s. Design pioneers Edward Kayser and Lionel Suttie led the way, followed over the years by: Bayly Design, Catalyst, Cobalt Niche, Design + Industry, Outerspace Design Group, Uno, and, most recently, David Flynn at Willow.

Wiltshire
Staysharp knife, 1969

Ian Wong, Monash University

In 1964, a US market survey showed that 80% of Americans didn't know how to sharpen a knife. Dennis Jackson, a design engineer for Wiltshire Cutlery in Melbourne, thought that a knife that sharpens itself was the answer – he had identified a whole new range of products with an advantage over any blade sold before. Stuart Devlin AO designed the first distinctive wall-mounted scabbard.
Peter Bayly designed the classic 1970s range for Staysharp, which was awarded the Prince Philip Prize and Good Design selection.

Kambrook
PB-1 power board, 1979
Robert Pataki

Ian Wong, Monash University

The first power board was devised by electrical engineer Peter Talbot in 1972 and assembled from existing electrical components. Talbot worked for electrician Frank Bannigan, founder of Kambrook Appliances, and the Kambrook power board first sold as a kit for caravan owners.
Power boards were soon being mass-produced and sold in Australian retail stores. The 1979 Robert Pataki design developed a configuration that would be replicated the world over. It was never patented.

9780170400336

Décor Corporation
BYO Wine cooler, 1978
Richard Carlson

Décor Corporation, www.decor.com.au

BYO (bring your own) restaurants were a feature of Melbourne culture in the 1970s.
The Décor BYO wine cooler was designed by Richard Carlson following a phone call from Décor CEO Brian Davis. Davis had just attended an awards event where a hessian bag printed with the letters 'BYO' had won a design award. In the 1970s he had often struggled to keep a favourite bottle of wine chilled in transit to one of the many BYO restaurants. He said, 'A plastic bag with ice cubes never really worked.'
The BYO design by Richard Carlson won the Prince Philip Design Award 1980, and is in the collection of the Museum of Modern Art.

Britax
Baby Safety Capsule, 1984
Robert Pataki, Phillip Slattery

Britax Safe N' Sound Australia

Every Australian under the age of 30 will have been required, when a baby, to have been taken home from hospital in a baby capsule designed in Melbourne.
Commissioned by the inventor, Robert Pataki and Phillip Slattery designed the world's first baby capsule. The Safe-n-Sound Baby Capsule won an Australian Design Award and the Prince Philip Prize in 1985. Baby capsules are now made around the world, and in 2013, the heir to the British throne, Prince George, went home in a Britax baby capsule.

Kambrook
Axis Eco Kettle, 1994
Eco ReDesign Program
Gerry Mussett, Paul Taylor

Ian Wong, Monash University

The Eco ReDesign Program in Melbourne in the early 1990s engaged major industrial design practices and major manufacturers with lasting impact.
The Axis kettle project, in particular, sought to influence energy consumption around the world as consumers used boiling water to make tea and coffee.
The lasting impact of the project, however, was the innovative round central cordless electrical connection, now standard on most kettles worldwide, that was developed during the project.

KeepCup
KeepCup *Brew*, 2014
Cobalt Design

KeepCup. Design by Cobalt Design

Concerns for the environment challenged designers and individuals the world over to reduce the waste from disposable polystyrene foam coffee cups. The majority of the patents that sought to solve this problem dealt only with the concerns of the cup of coffee, and not with the behaviour of the users. KeepCup is an inspiring example of systematic change. It was the world's first 'barista standard' coffee cup.
Founders Abigail and James Forsythe released KeepCup at the State of Design Festival in 2009. KeepCup, now global, has revolutionised the behaviour of consumers of great coffee.

321 Water
321 Water bottle, 2011
Charlwood Design

Charlwood Design

The 321 Water journey started in 2006 after founder Gretha Oost read the book *Troubled Water*, by Anita Roddick. A world where one person in every eight does not have access to safe water, and in which eight bottles of water are consumed every second, inspired this elegant personal water filtration system.
Designed and invented by Charlwood Design in Collingwood, the 321 Water bottle has a unique plunger filter mechanism. The ecologically sustainable design encourages the environmentally conscious user to carry and refill the bottle and carry the carbon filters, which are easily replaceable.

9780170400336

SECTION 4

UNITS 3 AND 4

Chapter 12: Unit 3: Applying the product design process 333

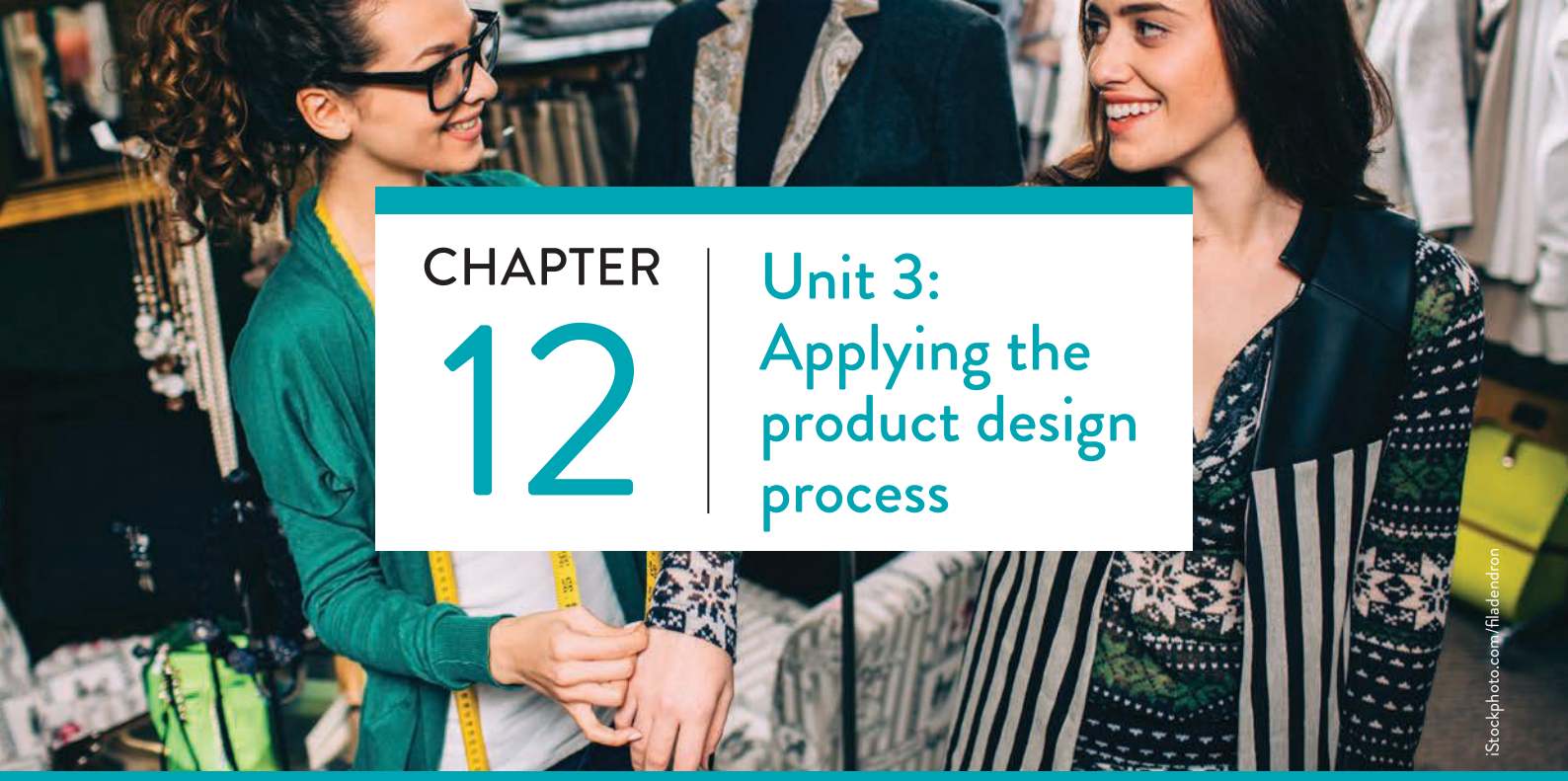
Chapter 13: Unit 4: Product development and evaluation 377

Chapter 14: The SAT: Folio, product and evaluation 389

Chapter 15: The Product Design and Technology exam 412

iStockphoto.com/FangXiaNuo

9780170400336



CHAPTER 12 Unit 3: Applying the product design process

iStockphoto.com/filadendron

CHAPTER FOCUS

In this chapter you will learn about:

Essentials for Unit 3 p. 333
- The product design process p. 334
- The product design factors p. 335

Area of Study 1: Designing for end-user/s p. 335
- The designer and end-user/s relationship p. 335
- Researching needs and gathering ideas p. 336
- The design brief and evaluation criteria p. 337
- Preparation for the SAT p. 342

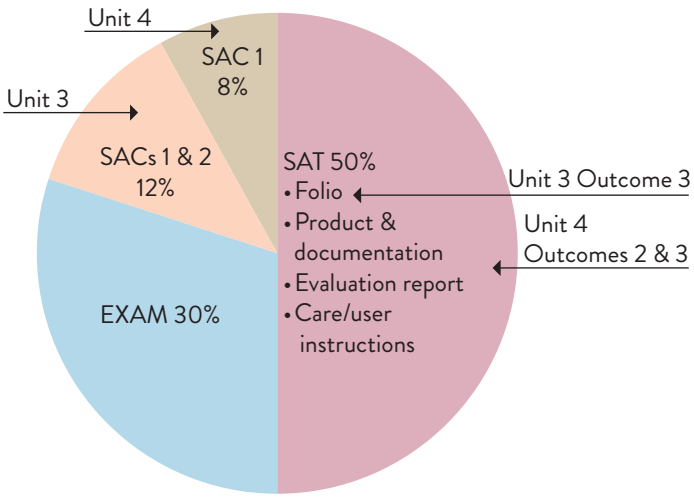
Area of Study 2: Product development in industry p. 348
- The role of research and development (in manufacturing) p. 348
- New and emerging technologies and materials p. 350
- The product development process (design, innovation and market research) p. 354
- Sustainability models p. 358
- Planned obsolescence p. 360
- Types of manufacturing p. 362
- Scales of manufacturing p. 362

This chapter focuses on the school-assessed coursework in Unit 3 – Outcomes 1 and 2. Outcome 3 is part of the SAT and is covered in Chapter 14.

ESSENTIALS FOR UNIT 3

Areas of Study 1, 2 and 3

Unit 3, Area of Study 1 (SAC 1) prepares you for the SAT and includes:
- designers and the end-user/s
- the stages, steps and goals of the product design process (focusing on Stage 1)
- the product design factors that influence designers
- how to write a design brief and evaluation criteria
- how to plan research and design activities from a design brief.



Overview of Units 3 and 4

Unit 3, Area of Study 2 (SAC 2) is where you learn about:

- product development processes in industry
- new and emerging technologies
- all the other influencing factors.

Unit 3, Area of Study 3 (SAT) is where you follow the product design process to research, plan, design and make your own product, continuing this process in Unit 4, Areas of Study 2 and 3. These three areas of study make up the School-Assessed Task (SAT) 'Folio, production and evaluation', which is your major project. *For more information on the SAT, go to Chapter 14.*

To revise the product design process, go to Chapter 2. You will also find relevant information in Unit 1 on page 247 and Unit 2 on page 268.

The product design process and factors

It is important to have a firm grasp of the product design process and the product design factors for Units 3 and 4.

The product design process

Goals of steps

In Area of Study 1, you need to describe the stages and explain the goals of each stage of the Product Design Process. *You can find a description of each stage in Chapter 2 and a clear diagram on page 10 of the* VCAA Product Design and Technology Study Design 2018–2022. Some brief explanations for goals of steps are set out below:

Stage 1 Investigating and defining

1 Identification of end-user/s, need, problem or opportunity – to create a starting point for the whole process; to decide what is needed and what can be created
2 Design brief – to define the design situation and give details of its requirements, including relevant parameters of the product design factors
3 Evaluation criteria – to emphasise the important points in the design brief, to identify the expected standard of the finished product, to keep the designer on track, to assist in selecting the preferred option and to evaluate the finished product
4 Research – to find out as much information as possible that will contribute to creating a great solution, and to collect inspiration

Stage 2 Design and development

5 Visualisations – to get many initial ideas down quickly in 2D and 3D forms
6 Design options (presentation drawings) – to present detailed, realistic possibilities from which one will be selected for the end-user (preferred option)
7 Working drawings – to give product specifications, i.e. of sizes, parts, placement, materials and to indicate methods of construction

Stage 3 Planning and production

8 Scheduled production plan – to list production steps in a suitable sequence; organise materials, tools, machines and equipment; manage time; prepare for safety issues; to prepare for quality work and budget accordingly
9 Production – to construct the product safely and accurately, to record progress for future reference and to communicate decisions

9780170400336

Stage 4 Evaluation

10 Product evaluation – to check whether the evaluation criteria were fulfilled; to look over the strengths and weaknesses of the finished work, check its quality, to reinforce knowledge and make suggestions for improvement

The product design factors

Along with the product design process, you also need to have a firm grasp of the product design factors – the factors that influence and impact on design. You will refer to these factors:

- when writing a hypothetical design brief in Area of Study 1
- at various stages of your SAT
- when analysing commercial products in Unit 4.

To revise the product design factors, go to Chapter 4. You will also find relevant information in Unit 1 on page 247.

AREA OF STUDY 1: DESIGNING FOR END-USER/S

Chapter 1 provides you with information about what designers do and how they work. Re-read this chapter to revise the approaches of real-life designers. You can also refer to any case study in this book.

The designer/end-user relationship

The designer's role

Designers' roles are similar, whether they are working individually or for a large company. They all work to create viable solutions to problems. Remember: a need, opportunity or requirement is often referred to as 'a problem that needs a solution'. Designers must look carefully at end-user needs to develop excellent solutions.

Whatever the circumstances or design field, a good designer needs knowledge and understanding to design and make products suitable for their intended purpose and to suit the end-user. They use design thinking, which is what you will do as you work through the design process.

A designer needs to:

- look for opportunities and keep track of new developments and new products in similar fields
- research and seek out relevant information related to the intended product (about the end-user, trends, materials, processes, regulations, intended environment of the product, associated costs, ergonomics, etc.)
- draw out necessary and helpful information from end-users
- use creative and lateral thinking to present a variety of ideas and options for solving the problem
- decide on the best solution and suitable materials, and work within a budget by balancing decisions about cost and quality

iStockphoto.com/Ingalvanova

As part of their research, designers may compare available colours with images from nature

9780170400336

- work within time constraints
- get feedback from end-users or peers
- satisfy the end-user needs.

The end-user

The end-user is, simply, the person who will use the product. It might be a specific person or a typical member of a target group.

workbook DFT end-user profile

The end-user's role is to:

- give the designer as much helpful information as possible
- give feedback on designs and/or materials and the finished product.

If the product is a one-off for a specific end-user then they will need to accept that changes may involve cost and agree to pay on completion.

The relationship

Designers need to ask questions, listen, observe and take notes. A diligent designer will put themselves in the user's position, collect information, record it, take photographs, etc.

To establish the needs of an end-user, the designer must develop effective methods of communication.

With a group of end-users, designers will partake in or refer to market research to identify end-users' needs. See below.

With one end-user, contact can be made in person, by telephone, by email or by mail, but the most common method is personal contact, initiated by either the designer or the end-user.

Whether the product is a one-off or being designed for a larger market, as many product design factors as possible are considered.

Research activities to identify a need: an example

When asked to design a work belt for employees at her father's carpentry business, Sam followed the workers around for two days. This helped her identify the activities they undertook and how they might perform them, and the safety aspects that would need to be considered. She observed them when they were involved in a task, as well as during their breaks.

Sam noticed how the workers needed to be unconstrained when they were working, how they needed to be able to reach certain tools easily on their body when standing on a ladder, how they needed to be able to use their mobile phones frequently and much more. She took photographs of them completing various activities from the moment they left home until they arrived back home after their day's work. She also took notes and measurements.

Market research

focus group carefully selected group of users to discuss and give feedback on their specific needs in relation to a product or prototype

Market research is defined as the gathering and analysing of data about markets and consumers. Market research can be carried out through observations, **focus groups**, interviews, questionnaires and social media, etc. It collects information such as consumer reactions about existing and potential products, and information on existing and potential users/purchasers. It is considered to come from either **primary** or **secondary** sources.

It helps companies to determine:

- the nature of their customers – what they will buy, when and where they will buy and how much they are willing to spend
- the demand for their products; features of products that are preferred (product design factors)
- what their competitors are doing.

This information can be numerical (quantitative) or descriptive (qualitative). Numerical data is suitable for large numbers and is information that can be scored or measured, e.g. on sales, preferences, sizes, etc. Descriptive information is more suitable for small numbers and expresses opinions, reasons and motivations. See more on quantitative and qualitative data in Chapter 13, Unit 4.

Some of this research will need to be conducted:

- before the product is conceived
- while it is being designed
- after it has been launched on the market.

Writing the design brief

Once the main issues are clarified, the designer will create a design brief for reference and complete any further research needed.

The design brief and evaluation criteria

To revise the design brief, go to page 12. It is a good idea to revise Chapter 4 before writing a design brief, to make sure you cover the relevant product design factors.

Once the needs and requirements have been established, the designer formulates a design brief. This sets down the requirements in writing. If designing for one end-user, it is an important document for both parties to see. Not all designers create an actual written design brief, but they will definitely determine details and take notes to refer to. You as a student must have a written design brief that is set out as required in this study.

In Unit 3, for both Area of Study 1 and Area of Study 3, you are also expected to write four-part evaluation criteria for the finished product (i.e. criteria question, justification, how it can be achieved and how it can be tested). These evaluation criteria come directly from the design brief – like a repeat of the important requirements but written in questions. Their purpose is to guide you throughout the process and to serve as a check at the end to enable improved outcomes in the future. *To revise the evaluation criteria, go to page 19.*

Once the design brief and evaluation criteria have been defined, the designer follows the product design process, which will often begin with research activities or idea experimentation.

Revise the structure of the design brief and evaluation criteria in Chapter 2 and set them out as shown in the table on page 339.

Researching needs and gathering ideas

To maintain an understanding of market, social and technological advancements and user needs, a designer must keep up to date. The best way to do that is to use both primary and secondary sources. Research activities provide further information about the end-user's needs and requirements and as many product design factors as possible. Some of the methods listed may be conducted before the needs are clarified in a design brief or later, during the design stages.

Primary sources

Primary sources of research are those conducted by the designer themselves, some of which could be considered market research. They can include:

- **looking** at the intended environment of the product, taking photographs, finding out about regulations
- **trying** existing products to complete the task/s; **examining** how they have been designed and created

- **observing** how people interact with similar products
- **devising and carrying out** a survey or questionnaire
- **organising** a focus group for trials
- **asking questions** of possible users, particularly about the function, aesthetics and material requirements of the intended product, e.g.:
  - What are the positives and negatives of existing products you use in this situation?
  - What exactly do you want the product to do?
  - What other functions would you like it to perform?
  - What safety issues are involved in using a product like it?
  - What sizes or measurements are important?
  - What strength does the product require?
  - Who exactly will be using the product?
  - What forces will the product be subject to?
  - What weather conditions will the product be subject to?
  - What quality are you looking for?
  - What style or colours, textures, shapes and line do you like?
  - What do you require of the materials? Favourite materials?
  - What level of sustainability would you like it to have?
- **listening** to end-user/s; making audio recordings of interviews
- **making suggestions** based on the designer's knowledge, gained from research or first-hand experience
- **measuring** spaces, components, users, etc.
- **taking photos** of inspirational objects, products from different fields and nature
- **exploring ideas**, e.g. shapes, colours, textures, proportions, contrasts, mechanical and functional features, and getting user feedback
- **trialling and testing** materials to determine their characteristics and properties and their suitability
- **trialling** processes, skills, ease of manufacture and available technology
- **checking** the availability and cost of possible materials.

Read the methods mentioned in the example box for a work belt on page 336. Is Sam using primary or secondary sources for information? Do you think Sam will gather quantitative or qualitative information?

Secondary sources

A secondary source of research is information collected and published by others, some of which could be considered market research. It can include:

- ergonomic information and relevant statistical data
- published information on possible suitable materials and their characteristics and properties
- images of similar products or inspirational ideas from the Internet
- statistical information on the intended consumer (target group) of the product, such as demographic information, income data and spending patterns
- published articles, including professional journals, newspapers, magazines, scientific reports
- legal documents such as patents
- social media such as blog postings, Twitter feeds, etc., which can be studied to obtain behavioural data and possible end-user sentiment.

You can see that quite a lot of the activities listed above could fit easily into the 'third part' of the evaluation criteria, which is titled 'how to achieve'.

Once research is completed, the design and development stage begins, followed by planning, production and evaluation. These stages are not required in Area of Study 1; however, they are a very important part of your SAT, and need to be understood.

Demonstrating your understanding of Area of Study 1

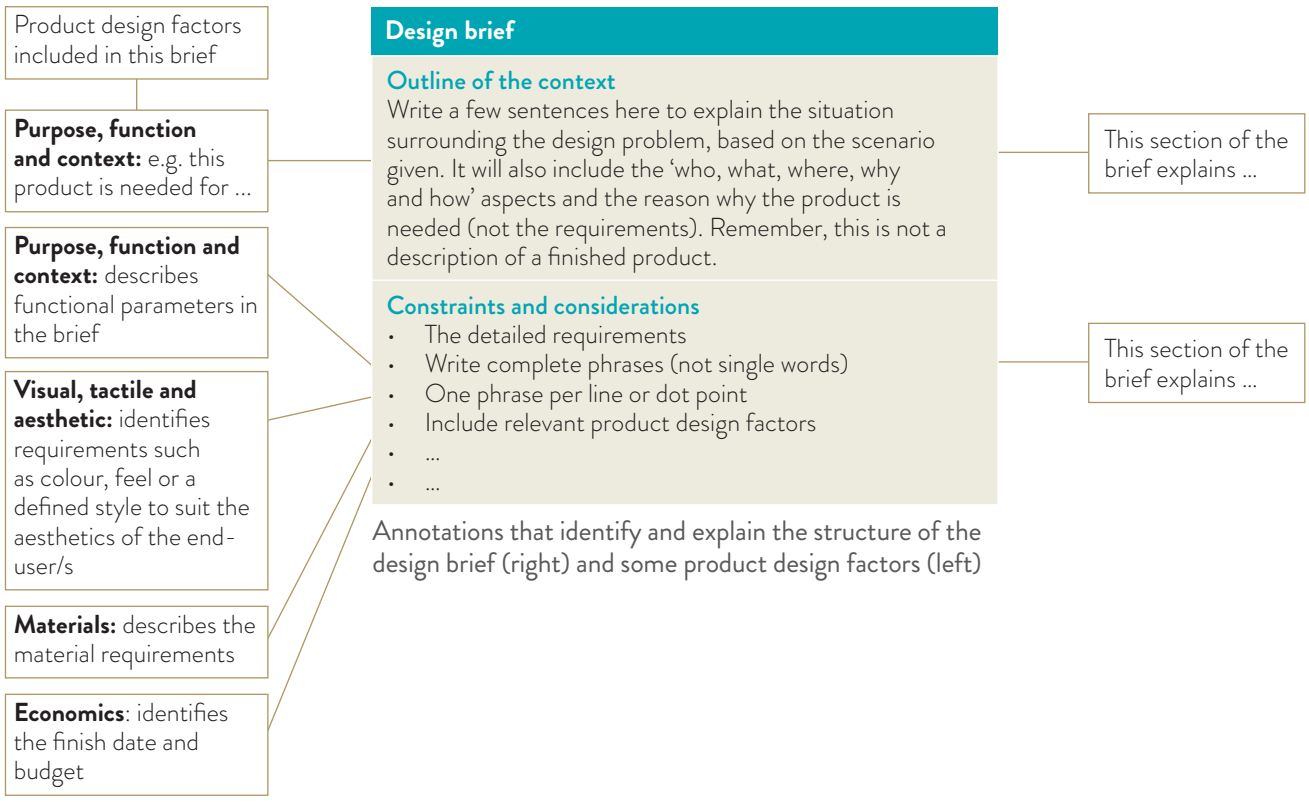
In Area of Study 1, you are asked to demonstrate your understanding of how designers use the 'investigating and defining' stage of the product design process and then apply that knowledge to move forward. You will be given a brief statement about a hypothetical design situation or scenario and you will be expected to expand on that information to create an annotated design brief and evaluation criteria that considers the relevant product design factors.

You will also be asked to describe the product design process or to demonstrate your understanding of it with reference to the design brief. Refer to the diagram of the product design process on page 10 of the *VCE Product Design and Technology Study Design 2018–2022*. From the brief, you will be expected to list specific research and design activities a designer could complete to help them create a suitable solution.

Constructing and annotating a design brief

Practise constructing design briefs as explained in Chapter 2. One method of practice is to use a reverse approach to create a design brief for a product that you own or have seen somewhere, or a brief for a product that you desire. However, remember that a design brief is a description of a problem, not a description of a finished product.

It's important that you understand the different sections of the design brief, what sort of information they contain, and which (broad) product design factors you have included, so that you can demonstrate this by highlighting and annotating them.



Annotations that identify and explain the structure of the design brief (right) and some product design factors (left)

9780170400336

Constructing evaluation criteria from the brief

For Area of Study 1, you are required to construct four-part evaluation criteria for the finished product, based on your design brief. They should include:

- evaluation question
- justification and relevance to the brief
- how it can be achieved during design and production
- how the product is to be tested or checked.

See how the evaluation criteria are laid out below. *To revise how to develop evaluation criteria, go to page 19.*

Evaluation criteria for finished product

Criterion	Justification	Ways to achieve	Check by
As a question Covers relevant factors from the brief	Explain why in the design brief	Several methods or strategies to arrive at the best decisions to fulfil the criterion	Concrete ways of checking how or whether the finished product meets the criterion

Highlighting the product design factors

Refer to the list of the product design factors and their parameters from page 9 to highlight and colour-code each one addressed in the brief. Use annotations to explain them, e.g.:

- The lamp **must adhere to 'Australian Standard AS/NZS 1680'** Interior Lighting

This belongs to the legal responsibilities factor because this is a mandatory standard

Using the brief to direct activities

Your next step is to suggest research and design activities for each of the highlighted factors that would help you design a great solution. For example: specific areas to be researched; materials or processes to experiment with or trial; ideas (such as colour combinations) that could be explored in drawings or models.

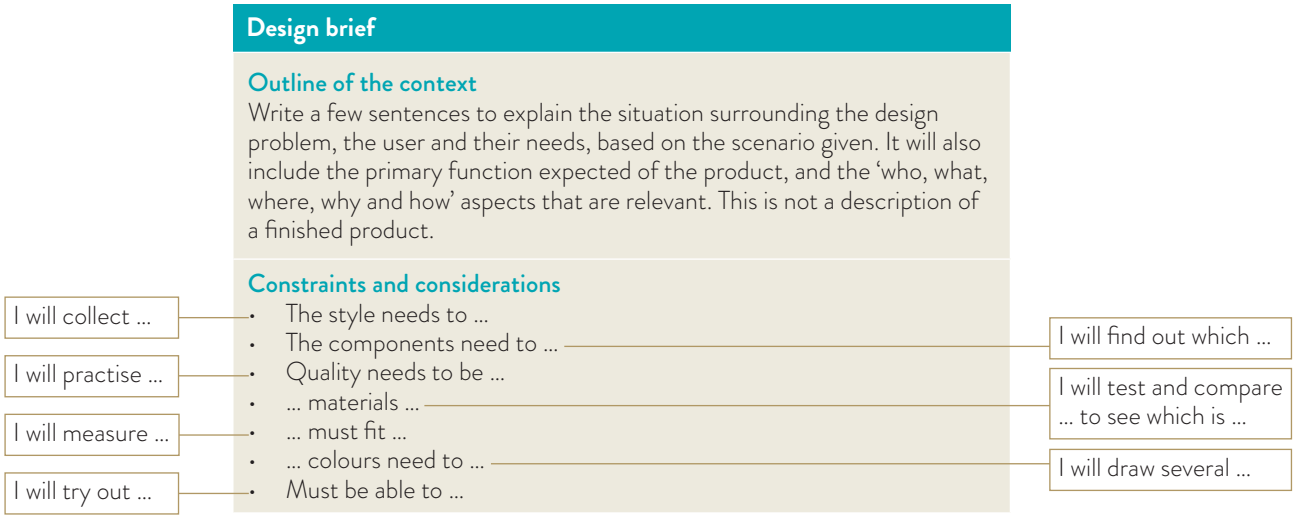
Some suggestions for specific activities:

- I will collect different handles and practise attaching them.
- I will find out which materials are strong, but with a bit of elasticity.
- I will get a costing of each suitable material.
- I will find out other properties of these materials by cutting them in several ways.
- I will find the best way to join them by trying out several methods and comparing them.
- I will observe an end-user using an existing work belt to see how they access it.
- I will research ergonomic data for the average size of hands to see how big the handles should be.
- I will research the availability of waterproof material widths and colours.
- I will explore combinations of colours that the end-user likes.
- I will draw lots of ideas for the product.

Include a list of the drawings that you as the designer could develop. State the type of drawing (from the conceptualisation stage of the product design process) and indicate what sort of information the drawing would illustrate, e.g. 'I will develop visualisations or sketches to work out the best silhouette for the body shape.'

List activities that would help achieve quality (related to several product design factors) such as functional aspects, selection of materials; and/or construction methods, e.g. I will practise cutting straight.

9780170400336



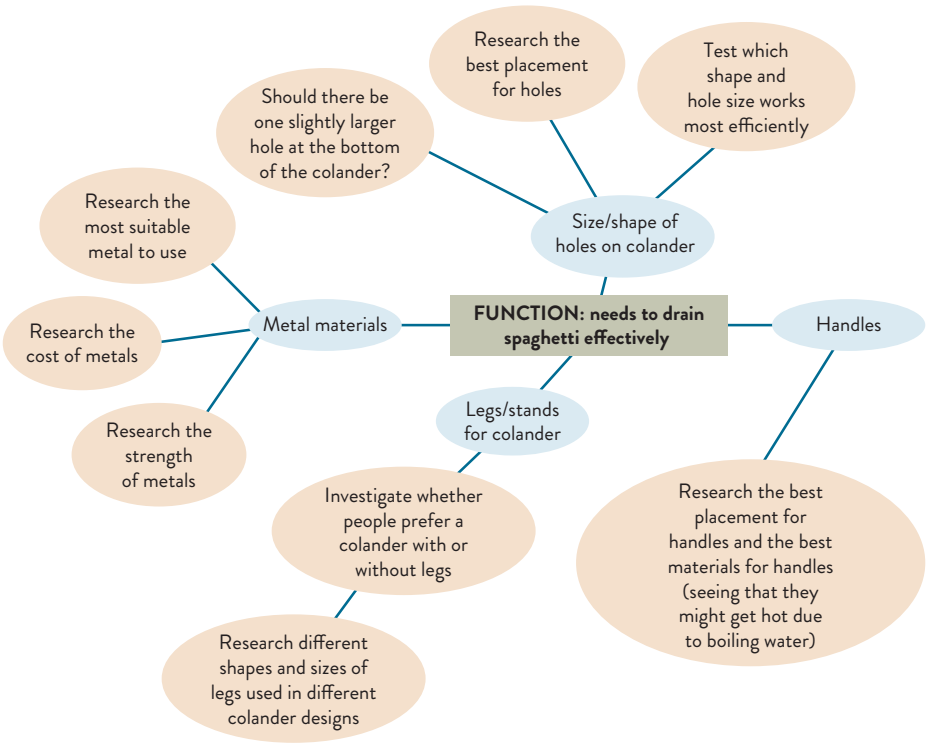
Annotations that identify possible research and design activities needed

You could choose to arrange your suggestions diagrammatically, using a graphic organiser.

Links to examples of a wide range of graphic organisers are provided at http://nelsonpdtvce.nelsonnet.com.au. Go to the Enchanted Learning website, scroll down to 'Other Topics' and select 'Graphic Organizers'. Or go to the Worksheetworks website and click on 'Miscellanea', then 'Graphic Organizers'.

Using graphic organisers

A graphic organiser is a visual method for organising information. Suitable graphic organisers for Area of Study 1 include concept maps, spider diagrams, star diagrams, lotus diagrams and fishbone diagrams. You can find examples and templates for these by typing their names into a search engine.



A mind map of suggested research activities for the functional and material requirements in a design brief for a colander

Remember, however, that graphic organisers don't need to follow rules – they can be any mix of text, diagrams and/or images.

Graphic organiser exploring possible materials, parts and design ideas by student Lachlan Hall, using inserted images, his own drawings and colour swatches

To sum up – the relationship between the steps in the first stage of the product design process is: the design brief states the need and requirements; the evaluation criteria emphasise and justify these requirements, and convert them into standards expected in both the design and workmanship of the finished product; research is conducted around the requirements, and the design stage develops ideas to satisfy the requirements.

Preparation for the SAT

Unit 3 Area of Study 1 prepares you for your major project (the SAT) almost like a practice run in the use of appropriate market research, how to construct a design brief, how to write evaluation criteria, and how to use graphic organisers to help you map out and organise research and design activities. These activities form part of the first stage of the product design process.

By learning about the product design process and the product design factors, you are becoming familiar with the important concepts that need to be understood in this study and demonstrated in your SAT.

CASE STUDIES FOR UNIT 3, AREA OF STUDY 1

CASE STUDY

Charlwood Design

Paul Charlwood established Charlwood Design – a full-service industrial design, product design and product engineering consultancy – in Melbourne in 1993. It provides and/or delivers innovative industrial design and product development services, across a range of industries including medical, consumer and technology products. Its work is global and designed to meet international standards, and has won many Australian and international accolades.

Emphasis is on designing products that resonate with target users and developing brands by immersing themselves in trends and desires.

9780170400336

> 'Empathy is central to everything we do. In our user-centred approach we question, listen, observe, interact and get to the core of our client's needs and the customer's desires.'

Charlwood Design is a Registered Research Agency, which means it is accredited by the Federal Government to complete research and development for companies (on a contract basis).

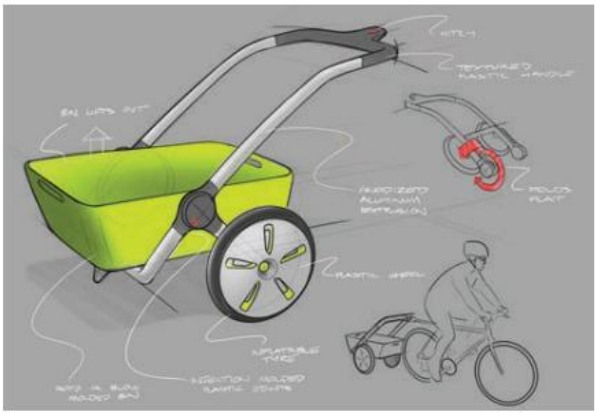
One example is the work it does with Oates cleaning products. They worked with elements that were key to the brand: a comprehensive colour strategy; function, form, innovation, value and sustainability. The Oates squeeze mop was redesigned to remove all metal components and resulted in three individual patented design features. The end result reduced production cost, increased quality and performance and, with the complete unit made out of polypropylene and free of adhesives, is fully recyclable.

Charlwood Design

The Oates squeeze mop

Another example is its work with start-up company KKUD Plum in 2016. Together they developed an innovative bike trailer and rack. Founders Astrid and Haydn Sharratt engaged Charlwood Design in 2014 with a brief to develop a trailer that could not only haul all your 'stuff', but could also double up as a fully functional shopping trolley – one that was easy and comfortable to push or pull around.

There were plenty of hurdles. The first issue was nailing the aesthetics. The 'pram' aesthetic was briefly explored – and just as quickly abandoned. Plastic wheels were dismissed very early on. And rolled tubular steel was favoured over aluminium extrusion, to provide a more traditional look. It was very quickly established that this trailer needed to look perfectly at home being pulled behind all sorts of bikes, or wandering the aisles of a city market.



KKDU Plum

A page from the first concept presentation

KKDU Plum

An early prototype. Water-knifed plywood was used to create a mock-up.

KKDU Plum

Attachment hitch and custom rack

9780170400336

Ergonomically speaking, the trailer needed to not only suit all bike sizes; but also all users. The solution was an incredibly easy-to-adjust handle that also doubles as the hitching location. The handle rotates up and down to suit a variety of heights of both users and bikes, and connects to a very neat little hitch hanging off the custom bike rack. This also allows for a push or pull configuration when removed from the bike. The rack itself has a multitude of length and height adjustability to fit onto most adult bikes, and is an amazing product in its own right.

KKDU Plum

Bike trailer and rack by KKDU Plum

The end result is a smart system made up of two key devices – the trailer and the rack. The trailer consists of an upper and lower tub for holding anything and everything. It has a traditionally formed tubular frame, fully adjustable handle that doubles as a hitch point for towing, and a fold-away third wheel to convert it from trailer to trolley in a matter of seconds. The rack, stunningly finished in bright chrome, is designed to fit most bikes. It is also the mounting point for the quick release uni joint hitch - an incredibly simple to use design that allows the trailer to be removed from the bike effortlessly.

'Stack it, pack it, bike it, love it!' – that's the motto for KKDU Plum. A great example of someone identifying a solution and doing something about it.

To read more about KKDU Plum and Charlwood Design, go to their websites. Links have been provided at http://nelsonpdtvce.nelsonnet.com.au.

CASE STUDY

Steve Martinuzzo from Cobalt Design

Cobalt Design, www.cobaltdesign.com

Steve Martunuzzo, Principal (rear) and Jack Magree, Principal (front)

Cobalt Design is a product development consulting business. It employs over 20 staff, who work with clients to develop products in the areas of transportation, health and science, consumer and sporting products, and products for industry and public spaces. Steve Martinuzzo is a founder and Cobalt's Managing Director and has a background in Industrial Design from RMIT. Steve shared some insights about his work and the focus of his company.

Teamwork is important at Cobalt. It's good to have a mix in a team – some specialists who are truly gifted in their 'thing', and some all-rounders who are good at many things. It is very similar to an elite sports team, in that you need specialists for a few specific roles, but otherwise flexibility, fitness and teamwork bring the greatest value to the group.

Cobalt Design, www.cobaltdesign.com

The Samaritan PAD defibrillator

Cobalt Design, www.cobaltdesign.com

Concave Halo football boot range

THE PROCESS OF DESIGN: USING DESIGN BRIEFS

In practice, most clients rely on Cobalt developing a brief as part of our proposal. Even where a client has created a brief, it often needs more work (for example, simplifying it where it's too complex; prioritising objectives when they ask for everything; or making it more strategic). We end up being good at brief writing because we do them so often, whereas most clients only create briefs occasionally.

RESEARCH TO DISCOVER THE USER'S NEEDS

We do this research whenever we can. As people are not especially good at telling you what they want, the ideal is to observe people using current products in as real a context as possible. We call what we learn 'user-driven insights' and they can reveal opportunities to uniquely improve products. In these cases, users will often say, 'Thank goodness someone has fixed that!' It's also important to remember that there is always more than one 'user' to consider. For example, the most obvious end-user of an EFTPOS terminal might be a shop customer. But what about the shop assistant, the shop owner, the IT company, the assembler, the client and the banking system? All of these groups of people (or stakeholders) have some interaction with the EFTPOS product or system, so all should be considered to some level.

We do most of our research in-house. Where specialised or market research is needed, our clients usually contract this themselves.

Cobalt Design, www.cobaltdesign.com

Design development for the Bombardier Tram project

9780170400336

DEVELOPING DESIGN IDEAS

Designers at Cobalt use all of the following methods: hand drawing, digital (tablet) drawing, CAD, prototyping (both physical and virtual).

FOCUSING IN ON THE BEST OPTION

Selecting the 'right' design is always an inexact science. In terms of process, we have some common principles but there is no 'one way' to select the best option. Each client, project and start/end point is different and we have to be flexible and adapt the process for each client. Effective communication is really important, and our approach and the amount of detail we give to a client at the selection stage depends on their knowledge and their need to be guided through the process.

HANDING OVER FOR PRODUCTION

A common point of handover is 'tool release', when we provide fully resolved 3D CAD files and engineering drawings/specifications ready for production tooling. But, as stated earlier, each client is unique and some clients don't need or want us to go that far, whereas other clients want us to be involved through tooling and into early production.

KEEPCUP *BREW*: A DESIGN DEVELOPMENT EXAMPLE

Cobalt had already worked with KeepCup to develop earlier versions of its sustainable, non-disposable coffee cup. The new KeepCup *Brew* is the result of Cobalt's design thinking process. Our process for the *Brew* included:

- **questioning the questions**. During the early phases of the project, we re-evaluated every assumption and aspect of the original KeepCup and how people use a reusable coffee cup. This involved questioning the way in which users interact with the product, listening hard to user feedback, and rigorously looking for product weaknesses and opportunities for improvements, or new features, materials and manufacturing technologies. User insights revealed that people liked to personalise their cups, and that they often like to drink from the rim (without the cap). We also looked at how far users carried the cups, and how long the coffee needed to be kept hot. These insights and observations were factored into the *Brew* design development.

The KeepCup *Brew* at different stages of design

The completed KeepCup *Brew*

KeepCup. Design by Cobalt Design

9780170400336

- **divergent thinking**. Divergent thinking considers a wide variety of ways in which a problem may be solved. Through several rounds of concept development and working closely with the client, we generated a large number of possible product concept ideas. Some of these ideas were radical, but others represented more subtle improvements to the already successful KeepCup product. The key element of this phase was the volume and breadth of ideas created.
- **iterative prototyping**. Iterative processes are those that use repetition. By building mock-ups, prototypes and trial tool parts, we were able to review and test functional design ideas, thermal and performance characteristics and material properties. Lots of rough prototypes were created early in the process. We wanted to explore as many 'big picture' questions as quickly and efficiently as possible, investigating performance and feasibility. The prototypes were then refined in terms of quality and effectiveness. This process allowed physical interaction, testing, evaluation and discussion.

Choice of materials

The *Brew*'s cup is made from glass, and it is available with a cork band. These materials are functional and environmentally sustainable (both materials are 100 per cent recyclable). The *Brew*'s glass cup is the same tempered soda-lime glass found in caffè latte glasses, making for a robust, break-resistant product – and one that will not shard into dangerous slivers of glass in the unlikely event of a breakage.

Cork is a wonderfully tactile and sustainable material that we have loved for some time. Cork is stripped from the bark of the cork oak tree, so the tree doesn't need to be felled for harvesting. Cork is biodegradable and fully recyclable, but it also possesses excellent chemical and thermal resistance, making it an ideal insulating material for the KeepCup band.

ISSUES THAT IMPACT ON COBALT'S DESIGN WORK

- **Sustainability:** We try to address this in every product we design.
- **Standards, patents and design registration:** These areas can have a big impact when the intent is to be comparable to but not to infringe on someone else's IP.
- **Economic pressure:** All commercial designs need to make a sustainable profit to justify the risk and investment in design and production.

WHAT IS GOOD DESIGN?

At Cobalt, we believe that good design:

- fulfils people's needs. Well-designed products work as expected. They must meet users' current and future needs
- emotionally connects. Good design recognises that people are not exclusively rational
- defines itself globally. Well-designed products are among the world's best of their type
- finds clear space. Good design creates clearly differentiated products
- is socially responsible. Good design reduces waste, hardship and resources. It is accessible and democratic, not exclusive to those with high incomes
- happens through teamwork. Good design is the result of multiple professionals working as a well-managed team
- is 100 per cent commercial. Good design generates success and profit far beyond the development investment
- needs clients with vision and technology. Design is the union of creativity and commerce. Good design only happens with good clients.

The company started a blog highlighting socially responsible design, sharing stories focusing on 'less waste, less use of resources, and creating less hardship' – hence the name: lessbydesign.org.

WHY DO YOU LIKE DESIGNING?

I like working as part of a team, and seeing our staff grow and be their best. I get real satisfaction in finding a new approach that makes an everyday product or task a little easier or more enjoyable to do.

Steve Martinuzzo was interviewed by Jill Livett in early 2017.

The Cobalt Design website has more information and many great product case studies. The KeepCup website has information about KeepCup's sustainability. Links to both have been provided at http://nelsonpdtvce.nelsonnet.com.au.

9780170400336

AREA OF STUDY 2: PRODUCT DEVELOPMENT IN INDUSTRY

Role of R&D in manufacturing

To remain competitive in a global market, it is important that industries invest in research and development (R&D).

trade deficit when the cost of imports is greater than the proceeds of exports

A prosperous country needs exports of a similar scale to its imports to avoid a **trade deficit**. Income earned from exports helps to pay for imports.

It is recognised that a healthy and viable manufacturing sector that includes exports, helps balance trade figures, and creates employment and opportunities for others. Strong employment equates with increased consumer spending, which contributes to even more employment. This in turn contributes to the welfare of society and 'quality of life'. Strong economic growth helps to raise living standards by stimulating enterprise, encouraging innovation and providing a positive environment for technological progress – all leading to an increase in employment and investment.

To combat this, many companies aim to be innovative in the area of design. While they may get their products manufactured offshore, they invest money and energy into making sure their designs are 'top notch'. This provides the company with a competitive advantage. To be competitive, innovation is required – not just in products, but in processes and systems. This requires big investment in education, training, capital equipment, and research into new materials and current technologies.

This type of investment is typically called R&D – research and development.

What is R&D?

R&D is scientific and technical, usually about the product, what it is made of or how it can be made.

The Australian Bureau of Statistics (ABS) website defines R&D as:

> systematic investigation or experimentation involving innovation or technical risk, the outcome of which is new knowledge, with or without a specific practical application, or new or improved products, processes, materials, devices or services.

Successive Australian prime ministers have emphasised the importance of innovation through R&D for the benefit of every Australian – to improve their quality of life.

The Australian Government supports R&D by funding university grants and several research agencies such as CSIRO, and by providing significant tax concessions to encourage private sector investment.

Explore the ABS website via the link at http://nelsonpdtvce.nelsonnet.com.au.

Forms of R&D

The activities that are classified as R&D differ from company to company, but they are related to developing either new products or new knowledge, i.e. to processes which may facilitate future product development. R&D may not give immediate financial gain so is often considered a risk on investment. It can be difficult to manage, as the researchers do not know in advance exactly how to accomplish the desired result.

According to the Australian Tax Office, R&D activities must be core or supporting.

- **Core R&D activities** must be experiments; they can take place in a laboratory or on a factory floor and are for the purpose of discovering new knowledge (not already available).

- **Supporting activities** are not experiments but are those activities that directly link to core activities, i.e. inform the experiment.

Watch the animations on Enviroloo (hypothetical case studies in relation to the R&D tax incentive). A link has been provided at http://nelsonpdtvce.nelsonnet.com.au.

Some of the forms that R&D can take are:

- inventing or developing new materials or new uses for materials (e.g. lighter, stronger, warmer, more elastic)
- looking at materials developed in other fields (e.g. food and medicine) and determining their suitability
- developing new equipment and machinery
- developing new ICT (writing the code and testing) in design and product manufacture.

It is important to note that market research and market testing are not considered R&D by the Australian Tax Office for tax incentives, as methods used are not normally experiments.

Use the link for a clear guide on R&D activities and those which are not eligible, and search for 'The R&D Tax Incentive – A Guide to Interpretation' published by AusIndustry.

Small companies can obtain R&D type of information by contracting other companies who specialise in the field. One example in the field of Product Design is Charlwood Design, Melbourne. *See the case study on page 342.*

Visit the Charlwood Design website. A link has been provided.

CSIRO

The Council for Scientific and Industrial Research was first established in 1926. It is now called CSIRO (the Commonwealth Scientific and Industrial Research Organisation), and is one of the largest scientific research organisations in the world.

CSIRO's main role is to carry out scientific research, in order to boost Australian industries, to benefit the Australian community and to 'develop Australia's scientific intellectual capital'. It also encourages the adoption of such research.

Many CSIRO research groups are involved in collaborations to help solve problems in all sectors of industry, such as those outlined in the information that follows. CSIRO negotiates contracts with organisations and individuals seeking scientific research expertise. Many other companies have 'spun off' the R&D provided by CSIRO.

Find out a lot more about what CSIRO does and its recent innovations from its website.

Shutterstock.com/Robyn Mackenzie

Research done by CSIRO was used in developing Australian banknotes made of a polymer substrate material

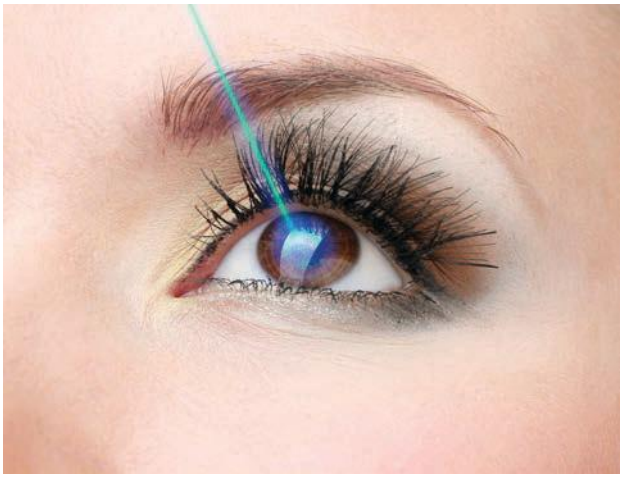
Banknotes

In the 1980s, CSIRO was instrumental in developing the polymer (plastic) banknotes that are in use today, replacing the old paper notes. The polymer notes are durable, have reduced counterfeiting and are recyclable.

Wi-Fi

In the 1990s, all online activity required fixed wires. CSIRO invented and patented wireless local area networks (WLAN) – the technology for wireless connectivity.

Today, it is used in phones, televisions, cameras, laptops, printers, routers and games consoles – estimated to be in more than five billion devices worldwide.



Shutterstock.com/Africa Studio

Laser technology is used for intricate medical procedures such as laser eye surgery, where precision is vital

Wool

In the 1950s, CSIRO developed shrink-proof wool. In the 1990s it pioneered Sportwool – a bi-layer knit fabric with wool on one side and either cotton or polyester on the other. A recent woolly development is Superwool, a fabric that is breathable, resistant to body odour and with elasticity. It used in suits for active office commuters.

Micro-joining technology and lasers

In the early 2000s, CSIRO developed micro-joining technology that can **laser**-weld 0.05 millimetre-diameter copper wire to 0.35 millimetre-diameter stainless-steel wire. Laser processes are now so precise they can engrave a human hair and perform delicate microsurgery.

laser
originated as an acronym for 'light amplification by stimulated emissions of radiation'

Wearable technology

CSIRO has groups working on projects such as:

- **ReMoTe** – a product that gives maintenance workers in remote locations access to a virtual pair of expert eyes and hands to guide them through difficult tasks
- **WASP** – Wireless Ad-hoc System for Positioning to allow coaches to monitor their athletes more accurately in indoor and GPS-poor environments
- **swarm sensing** – thousands of honey bees have been fitted with tiny sensors to monitor the insects' movements. It is being developed with Brazil's Vale Institute of Technology to take to the Amazon.

The above information about CSIRO was reproduced with permission from CSIRO Australia.

New and emerging technologies

In this section we will look at some new and emerging technologies, and examine how such technologies can influence product design.

Laser technology

Laser technology has become prevalent in production. It is used in one-off, low-volume and high-volume productions. It is extremely speedy, accurate and precise. Using intense beams of monochromatic light, lasers can cut through many layers at the same time and are safer than many previous cutting methods. They can also be used to take measurements of distances, levels, positions and speed. In clothing manufacturing they can also be used for embossing fabrics and to detect faults such as puckering of seams.

The first use of lasers in the daily lives of the general population was the supermarket barcode scanner, which was introduced in 1974. The laserdisc player, introduced in 1978, was the first successful consumer product to include a laser, but the CD player (beginning in 1982) was the first laser-equipped device to become common, followed shortly by laser printers.

Influence on design

Laser technology allows for more detail and complexity in designs that might have been avoided in the past for reasons of safety, accuracy and time.

Robotics

Robots, like lasers, are speedy, accurate and safe. They are made in many different forms, and can be programmed to work long hours, completing repetitive tasks. The use of robots has removed a lot of dangerous and repetitive jobs performed by workers in manufacturing.

Robots can perform processing activities, such as welding and painting, material handling, assembly and inspection.

iStockphoto.com/RicAguiar

Robots assembling cars

Influence on design

Robotics allows previously 'unsafe' procedures to be included in the construction of products. Robots can have different programs easily uploaded and can be programmed for smaller production batches, making them more flexible and responsive to consumer demand.

Computer-aided design (CAD)

In CAD, designs can be developed from scanned sketches or drawings, or they can be created from scratch. There are many CAD drawing programs, such as TurboCAD, Google SketchUp, AutoCAD®, Intercad, Pro/Engineer, SolidWorks and CATIA. All of them allow for 3D visualisation, which reduces costs and development times. Some programs allow for simulation in a detailed real-world context, to the extent that a physical prototype is not needed.

Influence on design

CAD allows changes to designs to be implemented quickly and accurately; avoiding errors in calculations. Designs can be emailed for immediate feedback, easily adjusted and stored electronically. This is a huge advantage over designs drawn and stored on paper or being sent by mail.

Computer-aided manufacturing (CAM)

CAM refers to the use of digital information (from CAD designs) to directly drive machines and manufacturing systems.

Companies use software systems to create instructions in CAD that work in conjunction with CAM, which controls technology such as lasers, routers, knitting and embroidery machines, and machine tools. Rip Curl, for example, uses the Lectra system to create CAD files, which are emailed to their factory in Thailand. Once the files are received in Thailand, the Lectra system (CAM) calculates the amount of material needed and creates instructions for manufacturing.

You can read about the use of CAM in the case study on Rip Curl on page 286.

Influence on design

CAM allows designs to become concrete speedily, increases accuracy by removing opportunities for human error, reduces material wastage and overlaps with the benefits of CAD.

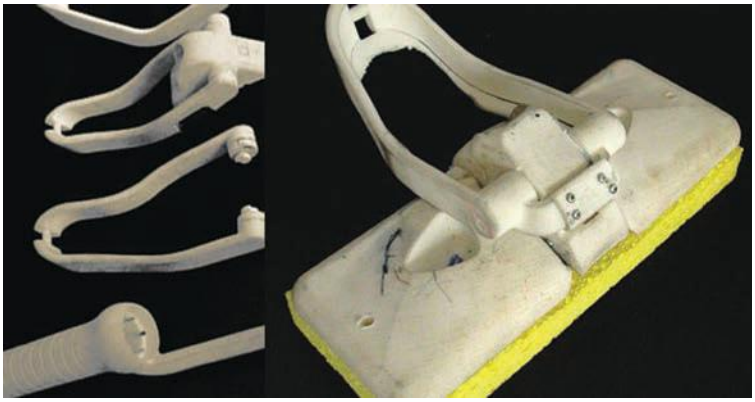
Computer numerical control (CNC)

CNC is the automation of machine tools (mostly drilling and milling tools) and the use of CAD/CAM programs in a series of highly complex steps to create parts and components. CNC has dramatically reduced the number of machining steps that require human action, along with making considerable improvements in consistency and quality.

CNC-like systems are now used for any process that can be described as a series of movements and operations. These include laser cutting, welding, friction stir welding, ultrasonic welding, flame and plasma cutting, bending, spinning, pinning, gluing, fabric cutting, sewing, tape and fibre placement, routing, picking and placing (PnP), and sawing.

Influence on design

CNC contributes to faster results and therefore easy updates to designs.



Charlwood Design

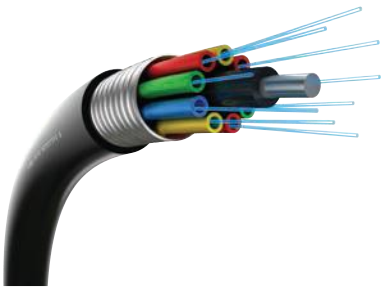
An example of rapid 3D prototyping at Charlwood Design: Oates mop

Rapid prototyping (3D printing)

Commonly known as 3D printing, but also known as desktop manufacturing, solid freeform fabrication or layered manufacturing, rapid prototyping is a speedy process used for building physical 3D models and prototype parts. A design is sent from a CAD program to a 'printer', of which there are different types. Some lay down successive layers of liquid plastic; others use UV or laser light to solidify powdered plastic, or to melt powdered metal. Research is also being done to find effective ways to form biological materials or structures using 3D printing. The main benefit of this process is a greatly reduced time to produce a prototype – in the past it could take weeks or months to make a physical model of a design. Rapid prototyping speeds up the entire product development process – the time from initial concept to consumer use.

Influence on design

A prototype of a design can be 'printed' literally overnight, examined, trialled and tested, and adjustments made almost immediately – again, a process that may previously have taken months.



iStockphoto.com/Henrik5000

An enlarged fibre optic cable

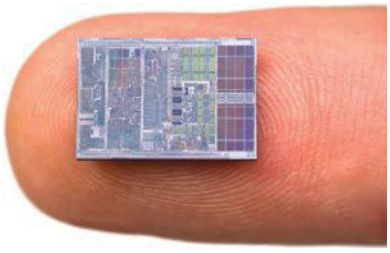
Fibre optics and the microchip

The two most important developments from last century are fibre optics and microchips.

Fibre optics

Telephone conversations or information signals (from computers) are converted into light using a laser and the beam is sent along a tiny optical fibre. This fibre is rather like a very thin glass tube, and when light reaches the other end of the tube, it is converted back into a signal by a demodulator.

A fibre-optic cable holds many fibres and may go from suburb to suburb or country to country (under the sea). They have a vastly increased amount of bandwidth (for transfer of data) compared with copper wire.



iStockphoto.com/kydna

An integrated circuit

Integrated circuits (ICs)

ICs, or miniaturised electronic circuits – commonly known as microchips – were originally a simple circuit the size of an adult's finger (consisting of one transistor, three resistors, one capacitor and connected wiring on a piece of silicon). Today, an IC smaller than a 5-cent coin can hold 125 million transistors.

Consider that the first computers in the 1960s needed an entire room to house them, whereas today computers are so small that some can be held in the hand. Not only are computers now much smaller, they are capable of doing a lot more and at a faster rate. They can take photos and send and receive data (e.g. users can do their banking and watch live football at the same time) without any wiring at all.

Almost all modern products use IC technology and, due to the amazingly small size of modern ICs, products can be made smaller and smaller.

At the same time, battery technology has also come a long way; they too have become smaller and more powerful. This is another factor that allows products to be smaller, as they don't need to house big batteries.

Along with all the new electronic products comes a market for accessories, e.g. handbags with pockets for mobile phones, snazzy colourful shoulder bags for laptop computers, and special niches inside vehicles.

New materials

The world of materials changes almost on a daily basis. New materials are constantly being developed by scientists, industry and individuals all over the globe. Some of these developments are radical and innovative, while others are **incremental**.

incremental development continual improvement in, or addition to, an existing material or product in a small way

Some examples are:

- miniature circuitry in fabric that can create materials capable of carrying dynamic messages, graphics or multicoloured surfaces
- fabrics that detect changes in heat or heart rate
- fibres filled with silver to be used to create bandages for burns
- plastics such as polycarbonate that are flexible, strong and easily dyed
- metals that can be moulded like plastic, made from alloys of zirconium, nickel, titanium and copper
- wood/plastic composites made from plastics, such as those found in old carpet fibres, and low-grade wood waste
- various crops that can be processed into fabric, such as soy, bamboo and corn
- carbon fibre – a light, flexible and extremely strong material that is usually used in a composite with other materials; used in bicycles and planes, etc.

Many new materials are patented or trademarked. Examples are:

- Recopol™ – a solid material made from e-waste such as computer casings, telephones and printer cartridges
- Poron® – cushion material used in shoe soles that is cushioning, flexible and breathable
- SPS MAX – used by Blundstone in the soles of boots. It includes XRD® Extreme Impact Protection, a lightweight, thin and breathable cushioning material that's engineered for repeated impact and shock absorption.
- Kevlar® – a bulletproof fabric, developed by Dupont, that is also used in jeans for motorbike riders, chainsaw operators, etc.

9780170400336

Biomimicry

Many scientists examine the structure and mechanical properties of biological materials, structures and/or animals to give them ideas for the improvement of materials and structures. For example:

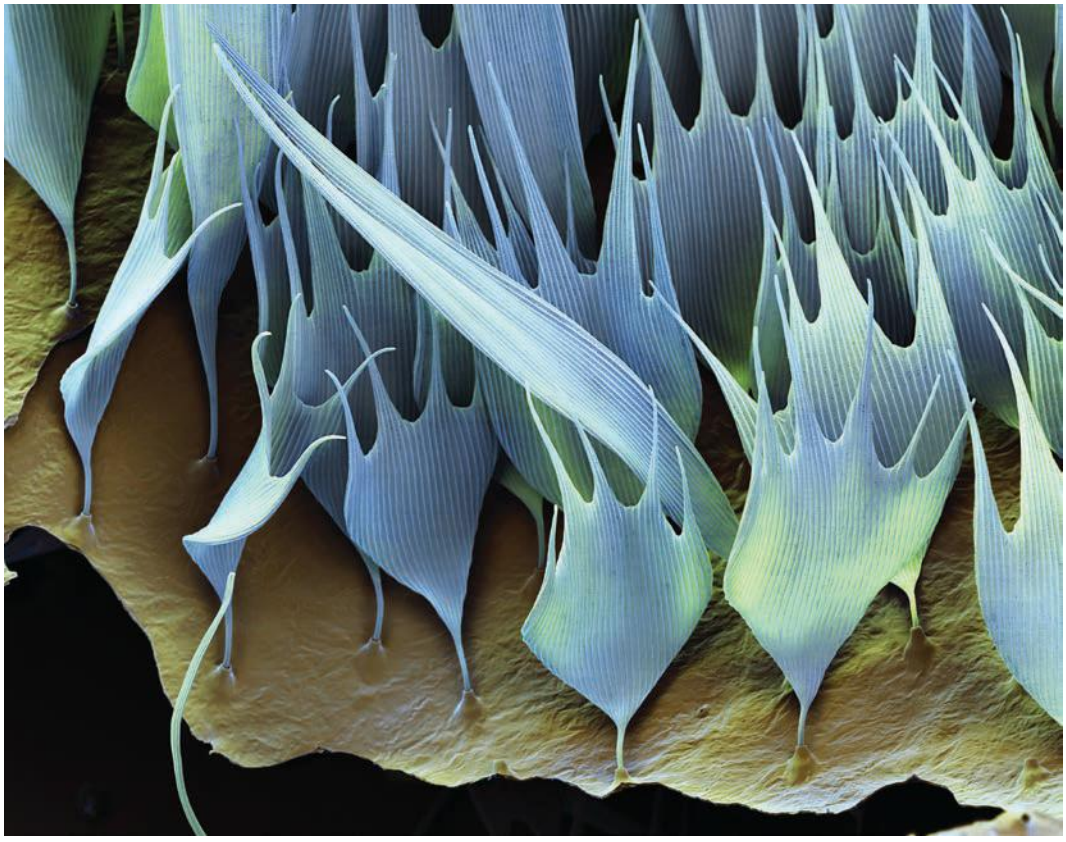
- the strength and fatigue of materials such as bone and shells
- the surface of moth wings, to see how they repel water
- the fibres of a spider's web for its strength and flexibility
- the surface of a cat's tongue and how it beats gravity when lapping milk
- the surface of a gecko's feet that allows it to cling to shiny surfaces.

nano
prefix meaning one-billionth, as in 'nanometre', or one-billionth of a metre

nano-engineering
engineering at a microscopic level

A functional understanding of the structure of natural materials can be used by those in the field of **nano-engineering** to recreate synthetic materials that function in the same way.

You can find a lot more detail on any of the technologies or materials mentioned here by simply using a search engine or going to the free online encyclopedia, the A to Z of Materials, at the AZOM website. For case studies on biomimicry, go to the Leonardo DiCaprio Foundation or the Biomimicry Institute. Links are at http://nelsonpdtvce.nelsonnet.com.au.

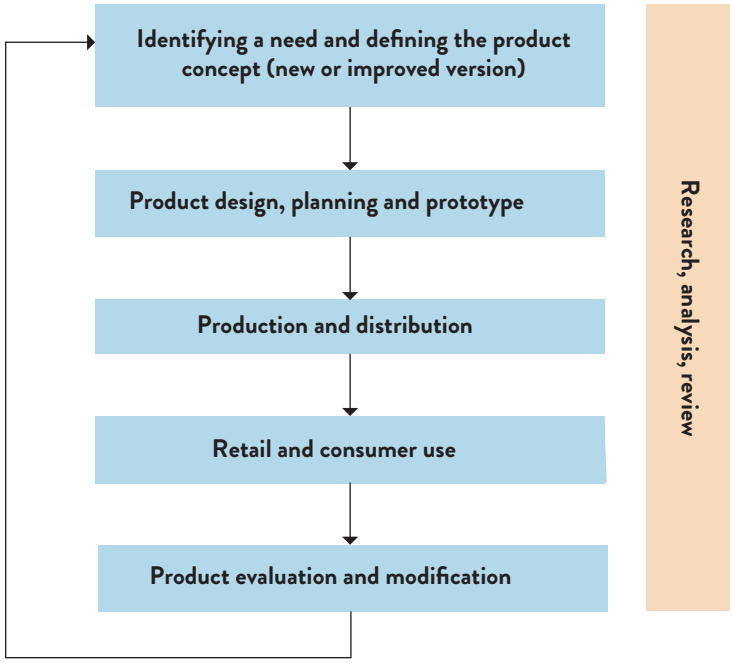


Science Photo Library/Eye of Science

A coloured scanning electron micrograph (SEM) of scales on the wing of a silk moth

The product development process

All products in mass production go through a variation of the product development process – from abstract concept, design, production and distribution, and then on to retail. Feedback from retail is an important part of the process and feeds into the next round of design and development, which could be for an improved version or a completely new product.



An example of the product development process

Starting points: concepts or identifying a need

New products may start from a range of possible triggers, e.g.:

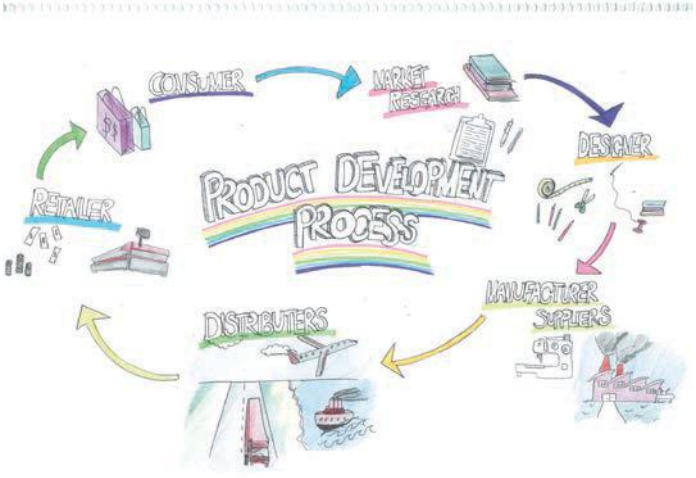
- recognition of a consumer or end-user need not properly met by existing products
- the need to replace or modify an old product that has become obsolete and/or unpopular
- access to a patent for a product concept or idea
- technological innovation that allows new products to be developed or existing products to be improved.

Research

When developing or modifying products, it is important to investigate relevant information and conduct trialling or testing. Areas of research include:

- market research – needs and interests of end-users, products by competitors, etc.
- the possible innovative use of materials and production processes (including the application of new technologies).

Research may coincide with and support other stages.



Graphic representation of the product development process by student Paige Anderson

Design and prototype development

Designers respond to market research or create something new. The design is prototyped, tested and developed until approved by the company. Issues are sorted out with prototypes or through computer modelling. It is then taken to a practical solution. Practical packaging solutions are also developed (if needed). Financial aspects are carefully calculated.

9780170400336

Production and distribution

Once the prototype or computer-modelled product has been finalised, it is put into production in small or large numbers called units. Components are outsourced if necessary (especially in vehicle manufacture) and suppliers are organised. The production process is carefully monitored, quality is checked at all stages, and modifications to the process are made if they are needed. Distribution and transportation methods move the product from the factory to wholesalers or retailers for sale.

Retail and consumer use

The product is sold through appropriate outlets or directly to the consumer. Increasingly, products are sold online.

Consumers use the product until it breaks down, goes out of fashion or becomes obsolete. They may replace the product, buy a modified version, or seek a new product to meet their need. Market research is adopted again to see what can be improved or what is going well.

Product evaluation and modification

Market research, in the form of sales data from retailers and consumer responses, is used to refine or modify the product. Information is also gained from the sales of products by competitors; all is used to evaluate the success of the product. If minor aspects of the product need changing, these changes are implemented with minimal alterations to production. Major product changes or redesign require the company to work through the cycle again.

The importance of design and innovation

You can understand why design and innovation is important by asking simple questions: 'What if a company did not do any design or innovation? What if they produced the same design in the same way, year after year?' Of course, there are some time-proven products produced in this way, but they are usually of very high quality and with a long and proven reputation.

Consumers now have worldwide access to unlimited products in a variety of price ranges. Some consumers may want something special or personal and may be prepared to pay a lot for it; or they may be prepared to search high and low for it. This item may be special because of the type of material used or because of something clever, beautiful, sophisticated, more useful, lighter, faster, easier to use or quirky about the design. An example might be a streamlined rubbish container made from translucent plastic, or a very expensive item, such as an ironing board made from zinc and steel that folds up perfectly.

When products are offered for equal price, it is design and innovation that gives a product the 'competitive edge'. Manufacturing companies are increasingly placing an emphasis on quality and are employing designers to give their products the edge. To catch the eye of consumers, they want their product to look great – to have style – to be carefully thought out, and to offer something 'new'.

The Knog Oi *bicycle bell is a good example of this.* *See the photo on page 10.*

Many department chain stores employ well-known designers to create a range of products, such as clothing, stainless-steel tea kettles, other kitchen items and wooden furniture. Target, for example, often invites well-known dress designers such as Jean Paul Gaultier (France), Stella McCartney (UK), Collette Dinnigan and Gwendolynne Burkin (Australia) to design a range at an affordable price.

9780170400336

Innovation in product development

For a company to stay in the market and be competitive, it needs to bring innovation into the product development process. This could be innovation in:

- the product itself
- the systems for organising the way the product is manufactured
- the way the product is distributed
- the manner in which the product is made available to customers
- the way the product deals with sustainability issues
- the service that is provided to customers.

Market research

You learnt about market research in Area of Study 1 (page 336). Market research finds information about who might want the product being developed, and the features they want it to have. It occurs throughout the product development process and is vital for the product's success. It can be broken into five areas known as the marketing elements.

The marketing elements

In marketing there are five elements, known as the '5 Ps': people, product, price, place, promotion. By defining each of these, a company can develop effective marketing strategies.

1 People: who will buy this product?

For marketing purposes, 'potential customers' are divided into target groups, and information about the tastes and needs of people within a group is pinpointed. People are broadly placed into target groups according to personal factors, their spending habits and where they live.

Market research is used to identify the characteristics, needs and aspirations of these different groups of people.

2 Product: what is being sold?

What is special about the product that makes it appealing to the specific target group, such as how it functions, its status, its price, its sustainability, its new technology or its appearance.

Market research is used to identify the particular features of a product's design (or improvements) that appeal to the target group.

3 Price: what is the price?

Price is determined by what a potential customer might be willing to pay. Pricing strategy considers the cost of competitive products. The cost of making and distributing the product has to be taken into account to ensure that it eventually creates profit.

Market research identifies the pricing level that the target group will pay for the product, and also what the potential consumer is looking for in terms of status, quality and value for money.

4 Place: where can it be bought?

The product needs to be placed where the target market do their shopping. For example, shoes with broad appeal – such as sports shoes – are available in department stores and smaller stores. Other types of shoes are sold in specific locations, such as seaside resorts, country towns, outer suburbs or inner city suburbs. Designer shoes, e.g. Manolo Blahniks, are sold in shopping strips around the world that are renowned for stocking other luxury brands.

9780170400336

Not all places for distributing or selling products are physical stores. Many products are sold through catalogues, direct ordering and the Internet.

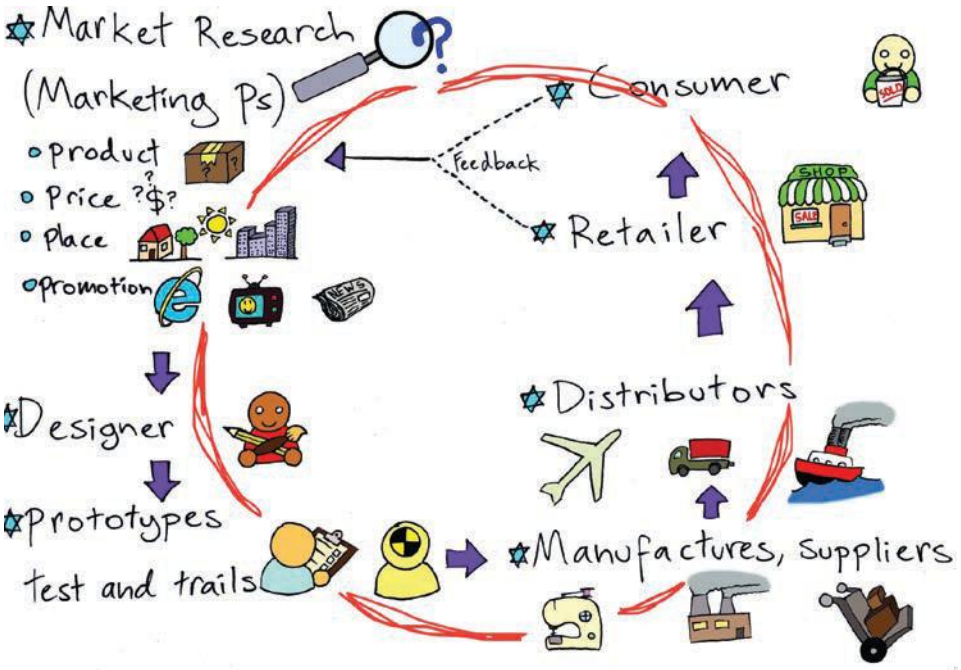
Market researchers find out where the target group for a product is most likely to do their shopping, and investigate their shopping habits.

5 Promotion: how will people know about it?

Promotion communicates information about the product, and to alert people (the target market) that it is available (where and how much).

This is done by: advertising; sponsorship; in-store demonstrations; direct mailing, emailing, phone calls and social media, i.e. Facebook, Instagram or whatever is current.

Market research is used to identify what sort of promotion strategy is economically feasible and likely to have the most impact on the target group.



A graphic representation of the product development process, including market research, by student Ollie Nwobu

Sustainability models

Sustainability models are also known as frameworks or strategies. A brief explanation of some of the sustainability models is provided below.

Life cycle analysis/assessment (LCA)

LCA is an internationally recognised and standardised technique (ISO 14040 series) for assessing the environmental aspects and potential impacts associated with a product over its total life cycle. It examines the sourcing and processing of the raw material, through manufacture, distribution, use and disposal.

A full LCA is particularly useful to evaluate the environmental impacts of a product or system with a high level of accuracy. However, it can be a time-consuming, resource-intensive and costly exercise because of the need to collect detailed inventory data for each stage of the life cycle (Sustainability Victoria). *Refer to page 123 for more details on LCA.*

'Cradle to cradle' concept (C2C)

The 'cradle to cradle' concept emphasises a recycling plan for the end of life of a product, so that the materials continue to be reused in some way. McDonough and Braungart emphasise 'up-cycling', where materials and the products made are of equal or greater quality after each round of recycling (rather than 'down-cycling' – being used to create lesser-quality materials/products, which eventually end up in landfill). C2C takes inspiration from nature's processes, where materials are viewed as nutrients in a healthy, safe system. The systems referred to are either biological (materials are composted or consumed) or technical (materials are reused or recycled).

Design for disassembly (DfD)

DfD takes the entire product – including its parts and components and how they are joined – into consideration in the design stage. It aims for easy repair (parts are easily replaced), minimal different types of material in a product, and labelling for easy identification of materials, so that recycling is easier. It also allows for the easy separation of materials that are incompatible for recycling. It is also known as DfR – Design for Recycling or Recovery.

Extended producer responsibility (EPR)/product stewardship

Extended producer responsibility (EPR), or product stewardship, is an approach that recognises that manufacturers, importers, governments and consumers have a shared responsibility for the environmental impacts of a product throughout its full life cycle.

EPR was developed to reduce the amount of waste from consumer goods. Producers take more responsibility for managing the environmental impact of their products, particularly at the end of a product's useful life. Producers can use strategies such as: designing products that produce less waste, use fewer resources, have less toxic components and contain more recycled materials. They are also expected to 'take back' the product from consumers when no longer useful and put it back into the manufacturing of new products.

There are many voluntary product stewardship arrangements being undertaken across Australia, such as the collection and recycling of mobile phones, mercury-containing lamps, newspapers and PVC products. However, many people feel that this approach should be enforced through legislation for many products.

To find out more about EPR, go to the Department of the Environment and Energy website and search for Product Stewardship (the most recent Product List). Look for the approach by NSW at the EPA NSW. Links are at http://nelsonpdtvce.nelsonnet.com.au.

Influence of the sustainability models on design, manufacturing, distribution and marketing

Influence on design

LCA – Choice of materials based on scientific research; all possible impacts (energy, waste, etc.) considered in the design stage

C2C – Chooses reusable or biodegradable materials so that products do not go to landfill; focuses on long-term useful products rather than fads

DfD – Restricts the number of materials, blends, laminates and paints in a design to allow easy recycling; incorporates snap lock fit systems into the design for easy disassembly

EPR – Follows DfD principles; designs quality products with the ability to be repaired or modified in the future

Influence on manufacturing/production

LCA – Carbon footprint is considered (when choosing energy source) and methods chosen to reduce water use and general wastage
C2C – Favours the use of less toxic chemicals (in dyes, etc.), puts waste to other uses where possible
DfD – Eliminates glues, labels different materials for easy identification
EPR – Aims for quality production methods and re-use of waste; reuses or recycles returned parts and products

Influence on distribution

All of the sustainability strategies would use similar guidelines when choosing distribution methods from factories to distribution outlets, such as minimising distance travelled (materials and finished products), audits to monitor efficient movement of goods, using direct routes, using efficient transport and packing methods and eliminating doubling up. EPR also puts systems in place for return of used products.

Influence on marketing

When marketing products, a company can appeal to consumer's desire to purchase sustainable products by:

- using scientific support (e.g. certified LCA or C2C) to verify sustainability status
- promoting products as having the potential for their materials to be reused or being made from recoverable/recyclable materials that won't go to waste or end up in landfill (e.g. DfD or EPR)
- labelling to clearly identify the manufacturer, along with instructions on the repair, reuse or return of used products (e.g. DfD, C2C or EPR).

Planned obsolescence

Planned obsolescence is considered to be inbuilt, i.e. it is in the design. There are three types of planned obsolescence:

- functional
- technical
- style.

Planned obsolescence is when manufacturers design a product to be obsolete within a few months or a few years. Manufacturers have a vested interest in making a product that has a limited life – a consumer will then buy another to replace it. However, this type of approach can be blamed for some very negative impacts on the environment and society. Consequently, more and more designers want to or are being encouraged to think sustainably and to follow a strategy such as those outlined under 'Sustainability models' (sometimes led by consumer demand for more sustainable products).

What is obsolescence?

Obsolescence is when something (a product) becomes obsolete. This is for various reasons, such as when it:

- is no longer useful or useable
- is out of date
- cannot be used with current technology
- is replaced by another product that is more efficient.

Some benefits and problems of planned obsolescence

Consumer	Producer	Environment and society
Benefits		
• Products are cheap • Products are easily replaced • Consumers can feel 'up to date' • Products can be more efficient and labour-saving	• Economic benefits for manufacturers and retailers (more products sold) • Business can keep evolving • Staff can be 'up-skilled'	• Increased employment and wealth for the community • Increased level of hygiene through use of disposable products (e.g. medical, food) • Many products make life easier and more enjoyable for people
Problems		
• Products don't last • Products cannot be repaired, or are difficult to repair • Replacement costs can be high	• Need to invest in re-skilling and new technology (both costly) • Constant attention to the product development process	• Increase in waste – more rubbish in landfill • Contributes to pollution of air, water and land • Uses up resources – materials, water, etc. • Requires a lot of energy

Functional obsolescence

Functional obsolescence is when manufacturers choose lower-quality materials and processes, knowing that the product will be less durable. The predominant reason is cost – materials that are more durable are often more expensive to source, to work with during production, and to transport. In the past, washing machines and refrigerators had an effective service life of 20 years or more. Now they are expected to last for five to seven years or less!

Some products are designed to be difficult to maintain and repair. Household items such as a toaster might have a plastic knob that breaks off and costs more to repair than a new toaster; or the workings of a watch might be totally sealed during manufacture so that it can't be repaired once it breaks down. This shortens the life of a product. Such products become disposable – they cannot be repaired and must be thrown away if something goes wrong.

In terms of future sales and the company's reputation, a certain level of quality and durability must be maintained, otherwise customers will not feel they are getting value for money. It is a fine balancing act.

Technical obsolescence

Technical obsolescence is when products become obsolete when a new technology or design feature/function is developed. Examples of new technologies that change products are: the microchip, small batteries, optical fibre, wi-fi, electric vehicles.

A product may still function well, but may need to be replaced because of a technological advancement, i.e. a new product is needed for the added features or capabilities. It is not considered important to make the casings of some electronic or digital devices good quality, as the technology within them is likely to be surpassed by a more advanced technology within a very short time.

Style obsolescence

Style obsolescence relates to the changing nature of trends and fashions. Products go through regular changes in appearance and style, which induces people to replace the older-styled

product with something more fashionable. *For a discussion of aspects of style that can change rapidly in fashion, go to page 100.*

Different types of products have fashion cycles of differing lengths. Clothing fashions change every six to 12 months, but for products with a longer life – such as furniture – fashions and trends change more gradually and over a longer period. Trend, fashion and colour forecasting are tools that some designers use to make their designs current and desirable.

Types of manufacturing systems

Lean manufacturing

Toyota Production System (TPS)
a system that raised the quality of Toyota's products after World War II and is used mainly by Japanese manufacturers

Lean manufacturing is an example of a system based on total quality management (TQM). It was defined in 1990 and is derived from the **Toyota Production System (TPS)**, which identified seven 'waste' areas. The TPS seven waste areas are overproduction, unnecessary transportation, storage of inventory (materials and products with no value adding), motion (unnecessary movement of people and machines), defects, over-processing and waiting.

Lean methods aim for less waste, or little to no waste in time, labour, materials and processes, with the purpose of improving value for the customer.

Lean manufacturing is also about creating a smooth flow and having processes run very efficiently to assist in minimising waste. Measurements, rather than opinions, are used to make decisions and improvements. It is about getting the right things to the right place at the right time in the right quantity to achieve perfect workflow.

Six Sigma
Six Sigma is another system based on TQM. Six Sigma, originally developed by Motorola in the USA in 1986, aims for near perfection – striving for 99.99 per cent of output without any defects.

Flexible and responsive manufacturing

Sometimes termed 'agile manufacturing', flexible and responsive manufacturing allows manufacturers to change production with little notice and without complicated or expensive changes in tooling. It means that manufacturers can cater to consumer demands for more customised products, and can respond quickly to changes in sales by updating styles.

Lean manufacturing supports this as it means that new raw stock can be bought as needed, and that production doesn't continue wastefully.

Robotic manufacturing has enabled faster changes between production modules. It only takes the time needed to download and implement new program instructions, rather than the expensive downtime required to retool a traditional production system. It contributes to a very fast product development process, i.e. getting the product from initial idea through to a product ready for sale in the shortest possible time (sometimes aided by the use of rapid prototyping).

Just-in-time (JIT)
JIT is a philosophy that is implemented in lean manufacturing and only produces goods to the specifications, in the quantities and at the time the customer wants them.
Note: JIT is not in the 2018–2022 Study Design.

Although an agile manufacturing approach has been used by automotive and product manufacturers for many years, the Spanish clothing company Zara has become known as the first clothing company to implement the agile manufacturing system or 'fast fashion'. The brand gained popularity quickly – women knew they could find something new and fashionable and that it wouldn't be seen on a thousand other women, because new styles were constantly being introduced (enabled by fast turnaround from concept to production). See 'low-volume production' on the following page.

To find out more about Zara, go to its website. Link via http://nelsonpdtvce.nelsonnet.com.au.

Scales of manufacturing

Production occurs at a number of different scales:

- one-off creations
- low-volume production

- mass (high-volume) production
- continuous production.

The suitability of the scale depends on the type of product, the demand for the product and the production facilities.

One-off manufacturing

One-off creations (or manufacturing) are when a unique article or a large product made to a specific design is required. Items are essentially handcrafted, but certain processes may be outsourced. One-off manufacturing can be costly in terms of labour and materials, but usually results in a high-quality, **custom-made** product. Examples include a piece of jewellery; an entire boat, plane or vehicle; a special outfit, such as a wedding dress; and custom furniture.

custom-made made to suit an individual or specific situation

Low-volume production

Low-volume production is often called 'job-lot' or 'batch' production; it is when a small number of products are made for a specific situation. An item can be manufactured locally in smaller multiples, compared with manufacturing offshore (e.g. in China), where manufacturers deal only in thousands of units to make it worth their while.

In low-volume production, designers and manufacturers can respond quickly to changes in market demand and adapt the designs accordingly. It is a method used by many designers working with specialised products that have a niche (e.g. boutique clothing) or an uncertain market, to fill a small order for a client in a specific location/building or for a special event. While costs are involved to adapt the machinery for changed designs, it is usually financially beneficial in terms of only producing what is likely to sell. *See more under the heading 'Flexible and responsive manufacturing' above (page 365).*

Mass (high-volume) production

Mass production is the production of thousands, and sometimes millions, of items. This process is standardised and usually inflexible, but gives the greatest economies of scale. Mass production needs to be planned carefully as it is time-consuming and expensive to set up. It can also be risky financially – manufacturers need to be sure there is a market for their product if they are producing thousands of units.

Production-line or assembly-line production is a type of mass production often dedicated to completing a single, complex product, such as a motor vehicle. Here, component parts are assembled and processes are carried out in an order that provides the end product economically. It involves robotics, and skilled and unskilled workers (this form of production is suitable for high-volume and continuous production).

Continuous production

Continuous (volume) production occurs 24 hours a day, seven days a week, and is usually run by computer-aided manufacturing (CAM) systems. It has no interruptions. It needs to be monitored so that any problems are quickly detected.

9780170400336

A comparison of two scales of production

One-off production	Mass/continuous production
The people who make the products are multi-skilled, and the entire product is overseen by one person.	The workers may require limited skills or one specified skill, or may work on only one part of the product (piece workers).
This type of work may be varied and interesting.	This work may be repetitive, boring and dull.
The creator/maker may gain the satisfaction of seeing the product completed.	Factory workers may only see one part of the product that they produce.
One item is produced at a time, and each product is individual (no two products are exactly the same).	Hundreds or thousands of the one product are made.
It may take a long time to produce a product.	The average time taken to produce each product is reduced.
The cost of making the product is usually quite high, as materials may need to be purchased at full price.	The cost of each product is lowered, due to 'economies of scale' – a cheaper price for buying large quantities.
The quality of the product depends on the skill of the creator/maker.	The quality of the product depends on the accuracy of the machines, and the systems and staff that run them.

Examples of different scales of manufacturing for a chair

One-off for ...	Low-volume for ...	Higher volume for ...
• the Prime Minister • the chairman of a board • a play, TV or film • as a special commission or gift for a special person.	• an upmarket restaurant • the foyer of a five-star hotel • the office of a large company • a large house used for entertaining.	• school chairs • seats in a theatre • food courts • regular household chairs.

CASE STUDIES FOR UNIT 3, AREA OF STUDY 2

CASE STUDY

Marc Pascal: industrial designer

Marc Pascal studied fine art at the Victorian College of the Arts, and later industrial design at RMIT. His studio is a large warehouse space in Thornbury, where he works, thrashes out designs, makes prototypes, experiments with materials and processes, and organises business.

Marc designs and makes contemporary architectural lights, vases and other functional aesthetic pieces. The main materials used are polycarbonate (plastic), urethane rubber, stainless-steel wire, porcelain, technical gypsum and electrical components.

INSPIRATION

Inspiration comes from things such as butterflies, autumn leaves, the human form and flowers. Lighting such as the *Orchid* was inspired by the wholesale flower market in Footscray, with its huge variety of fresh flowers and particularly unusual orchids; along with lithographs of orchids over 100 years old in the Rare

9780170400336

Books department of the State Library of Victoria. This work was also influenced by ikebana, the disciplined Japanese art form of arranging flowers. It hangs from a single wire, as do all of Marc's pendant lights.

The *Leafy Sea Dragon*, inspired by its namesake, was developed over four years; it's a different kind of pendant in a new series for Marc. It has a 'body' to house the electrics, and translucent protruding arms that emit the light.

Favourite artists are also an inspiration: Joan Miró, Issey Miyake and Alexander Calder, to name a few.

CONSTRUCTING THE *ORCHID* LIGHT

All of Marc's lights are constructed in a similar manner, which achieves a complicated 3D effect. To get the plastic to mimic a flower such as the orchid, the polycarbonate is rolled around an aluminium tube, wound with rubber and put into boiling water. It relaxes into the shape and comes out of the water with a 'new memory'.

The pieces are dyed up to three times. To give sophisticated colourings, there is a lot of playing around with the 'interference dyeing' technique: a piece of rubber is rolled around the pieces differently each time, and small templates of shapes are pressed in between layers to limit which parts take up the dye. Polycarbonate takes dye almost photographically, and Marc has created a large library of colours.

Shutterstock.com/Nadezda Verbenko

A vibrant orchid flower

'Each flower is dealt with individually and each light has tens of flowers; every flower is unique – not repeatable,' he says.

To increase the tension, the polycarbonate is curled back on itself and the stainless-steel wires are inserted

Marc Pascal

A close-up of the wire inserted into the *Orchid* flower petals

about 12 millimetres into the rubber ring base. The stainless-steel wire gives kinetic movement, allowing the shapes to catch any breeze or movement in the room, and drawing out a play of light and shadow. 'It is reminiscent of butterflies fluttering or leaves falling in autumn – natural and random,' explains Marc.

The *Eyoi-yoi*, *Acacia*, *Xploff* and *Orchid* lights all use the same electrical system. Material is moulded around the lamp holders via silicon moulds and fixed to the pendant, table or standard (floor) stems.

'The strength in my products is the modular colouring system, which is bespoke (made to order). Each one-off light is made up of 80 per cent translucent whites, with the client choosing the remaining 20 per cent from a myriad of colours. The combinations have to be considered and arranged carefully, and there are a lot of creative choices that have to be made. We (my

Marc Pascal

The pendant version of the *Orchid* light

9780170400336

makers and I) like each light to have small communities of colours that relate to each other, talk to each other, like little groups of trees on a hill.

'I think about the effect the light will have on a room and around people. I want products that improve the world and how people feel; to create tranquil spaces,' continues Marc. 'Seven of the *Orchid* lights were hung in the waiting room of the Dandenong Hospital emergency department – what a great curator!'

DEVELOPING THE DESIGNS

Marc will often do hundreds of drawings (mixtures of pen and paper and computer) for the one object, to refine the idea. Although the product is fully developed on computer – Marc uses Rhino 3D – a mock-up is always made. 'A mock-up allows the designer to check out the play of light on the object and to go over "how to make it" and to look for any possible problems, as there is always a problem to iron out.'

Marc Pascal

Orchid flowers are cut from polycarbonate and hand-dyed on a bench in the studio

PRODUCTION AND PROCESSES

Marc makes small production runs (batches) and one-offs (often to order). This allows him to maintain a uniqueness and quality that is not usually seen in mass-produced objects.

Many of the production processes for his other products are outsourced, where they can be completed on a scale, and with a quality, accuracy and speed, not possible in the studio. However, dyeing for the lights always takes place in the studio, where pieces are coloured by hand.

DISTRIBUTION AND PACKAGING

Marc's products are distributed/transported to select design stores and individuals, including interior designers and architects, across the world. The packaging must protect the product and each box needs to be exactly the right size. Sturdy, reliable boxes made of high-quality double-walled cardboard are essential. The lights are suspended in their box in a tube and are held securely. Cost and storage of the boxes must also be considered: it's cheaper to buy hundreds of boxes in one order, but they all need to be stored.

The boxes include instructions for assembly and use (occasionally lights are installed upside down!), and how to clean and care for the product: remove the shade from the stem, spray with a hose or agitate in a hot soapy bath, and drip dry!

EXPLORING MATERIALS

Knowledge is gained through communication with a network of suppliers, Internet sources, libraries, and what can be gleaned from industry.

Experimentation with materials and processes (like in a back shed) is important and provides a lot of useful knowledge on how materials can be manipulated. 'Of course, this is a very time-consuming aspect and requires a certain frame of mind or "play mode". It's a time when the designer needs to be in an inquisitive mood and ask, "What if I bend this or join that?"'

Typical experiments include dyeing plastics, trying new ways of applying colour, testing the stability of the dyes in different situations, playing with the interference dyeing technique by making small shapes to press in between the layers, checking the colours in different lights, testing the effect of heat on different materials, and even trying out unusual combinations of materials.

'It's important to stay abreast of the latest materials and processes,' explains Marc. 'This can lead to using more environmentally benign and safer materials, and faster or more efficient processes. Polycarbonate is not such a good material from the Earth's point of view, as it uses toxic chemicals in the making of it, but it's an excellent material from the end-use point of view – it is lightweight, tensile but flexible, can be creased and folded, really tough and long-lasting, can be either opaque, translucent or transparent, and can be coloured to any shade!'

9780170400336

Marc Pascal

Marc ponders a mock-up for the *Opposite* screen – an overlay of coloured, cut-out polycarbonate sheets to be inserted into a bamboo screen

QUALITY MANAGEMENT

Many trials are carried out on materials during the design process to ensure durability, reliability and therefore safety. Tests are performed beyond the requirements of the finished product, e.g. testing a material's ability to cope with heat by subjecting it to higher temperatures than it is ever likely to be exposed to in the end product.

Prototypes are checked and any problems are ironed out before further production. Marc often has up to three people working for him and has found that his 'makers' – and occasional interns from Europe – have helped keep quality up, by suggesting things and coming up with new ways of doing something. However, vigilance is required from all to ensure the quality they know customers expect.

MINIMISING WASTE

Material is used sparingly; shapes to be cut out of sheets of polycarbonate are marked out close together, but also with a view of creating a pattern so that the left-over off-cut sheet can also be used in a design, such as the *Opposite* screen, pictured above. Scraps are also valued – they too can be incorporated into a new design.

Lighting designs incorporate light-emitting diode (LED) technology. LED chips are extremely common in lighting now, as they not only cast a bright light, but use one-tenth of the amount of watts, last 50 times longer, and are less likely to break than traditional incandescent lights. Marc's LED pendant lights have a rubber 'hub' housing an internal metal 'root' system that distributes the 12 volts needed to run the lights to different 'branches'.

This allows an LED globe to be placed anywhere within a 700-millimetre radius of the centre; a highly suitable method to illuminate his beautiful pieces and hang them from a single suspended wire.

To find out more about LED technology, try typing 'LED vs incandescent' into a search engine.

AUSTRALIAN STANDARDS

Marc has all his lighting checked by an electrical engineer and approved for Australian Standards (AS/NZS 4417.2: 2001). Some examples of the requirements to be complied within this standard are:

- All wires must have double insulation.
- Any cord going into a metal tube must have a cord grip to protect it (to prevent the cord being ripped and severed by the metal).
- The switch and the lamp holder have to be tested.
- The stability of the whole structure has to be tested. Table and floor lamps must stand and not fall over when placed on a surface with a 12-degree slant.

MARKETING

Invitations from craft and design magazines to have a profile presented are happily accepted, and the annual Designex trade shows in Melbourne and Sydney are also important promotional opportunities. At trade shows, designers set up a space with samples from their product range. Trade shows are important, as they are the main method of communication used to attract buyers, the most lucrative being interior designers and architects, followed by shops and (to a lesser extent) individuals.

9780170400336

BROCHURES AND E-PROMOTION

A brochure is required for most trade shows and this is a crucial part of promotion. It is used to showcase the work and provide contact details. The brochure can then be used in other situations for the same purpose. A web presence is also crucial, as it can be updated quickly and show a large range of work. It may also be the first place where buyers will search for products.

For more information on Marc and for colourful representations of his work, go to the Marc Pascal website. A link has been provided at http://nelsonpdtvce.nelsonnet.com.au.

Marc and his work, along with many other contemporary designers, have been profiled in the book *Studio: Design at Work* by Donald Williams (MacGraw Hill, Melbourne, 2005).

Jacinta O'Leary spoke to Marc Pascal in 2017.

CASE STUDY

Tim Garrow

WHAT IS YOUR ROLE AND WHO DO YOU WORK FOR?

Tim Garrow is a product design engineer for Blackmagic Design in Melbourne. The company designs and makes its own innovative video technology, producing an end-to-end suite of hardware and software products. This ranges from cameras to software for colour grading of film at post-production. The company's products are known not only for their quality, but for their affordability. They are commonly used to produce Hollywood films, advertisements, TV and news broadcasts all over the world.

In 2016, Blackmagic Design was the first Australian company to be awarded the **Red Dot: Design Team of the Year**, considered one of the most prestigious design awards in the world. Four of its products also won Red Dot awards in 2016 and were on display in Essen, Germany, in a special exhibition called Creative Video Revolution by Blackmagic Design.

reddot award
product design

Courtesy of Red Dot

WHAT DID YOU STUDY?

Tim started his design journey with Visual Communication and Design in Year 12, followed by Product Design Engineering at Swinburne University. This was a mesh of technology and design, with subjects such as mechanical engineering, thermodynamics, manufacturing processes and components on design theory, design history and sketching. Students were given design projects in which they were expected to apply knowledge gained in the engineering subjects.

Tim Garrow, product design engineer

This course had several enticing aspects – among them, international exchange programs and a compulsory internship. It also had a strong emphasis on industry-based learning and involvement. In his second

9780170400336

year, Tim won a competition for his tap design as a response to a design brief from Phoenix Tapware. He was shortlisted for another prize with two other students in a worldwide Sustainable Design Challenge hosted by EDF Energy. The team designed a beautiful-looking system to convert organic waste, firstly, into methane to be used for cooking and heating in restaurants and, secondly, as compost for gardens. They were lucky enough to fly to Saint-Étienne, France, to see their work exhibited.

Read about their Gastrom Biogas Digester and Outdoor Heater. A link has been provided at http://nelsonpdtvce.nelsonnet.com.au.

In their final year project at Swinburne, students are expected to work with an industry partner; someone who can provide relevant data or knowledge to the brief or is able to give feedback for design, manufacturing, materials or costs related to the product. Tim worked with Albion Sports on an open-water helmet for lifesavers in racing competitions.

EDUCATIONAL EXPERIENCES

Before his final year, Tim spent an exchange year in France in 2010–11, studying at the Université de Technologie de Troyes (UTT) in the Champagne region. All lectures and instructions were in French, but the focus on group work and the necessary discussions aided his understanding. Almost every project had a team approach. Field visits were also part of the deal and advantage was taken of the town's history in textile manufacturing to visit factories and observe workers, etc.

For his six-month internship he worked with Blue Sky Design, a design consultancy group in Sydney. Like any design consultancy, Blue Sky Design took on projects for clients. Tim got to experience this type of work – very different to his current position at Blackmagic, where design is done in-house.

LIFE AT BLACKMAGIC

Tim began working with Blackmagic in 2012. At Blackmagic, almost all of the work involves working as a team. Tim's role is to transform a product from the concept stage, through the manufacturing (making of parts) and production (assembly of all parts) stages, into a working product that a customer can purchase.

Blackmagic Design's *URSA Studio* viewfinder

URSA Studio

URSA Studio, showing viewfinder rear

URSA 4K EF

All images on this page: Blackmagic Design Studio

9780170400336

When designing a product there are many factors to consider:

- its framework or visual appearance
- ergonomics to suit the user
- the manufacturing methods for its construction
- the costs
- materials selection for parts based on mechanical properties (hardness, strength, density, weight, thermal conductivity, etc.)
- material aesthetics and suitable finishes
- the assembly method.

Through his first-hand experience of working on a wide range of projects, Tim has gained knowledge of the advantages and disadvantages associated with these various factors. In relation to manufacturing, he has learnt so much about materials, e.g. which are suited to moulding, and the thicknesses required for strength in walls of parts. He has also learnt a lot about processes, e.g. the capabilities of each manufacturing technique to hit tight tolerances. He has worked on parts made from CNC-machined aluminium, plastic injection moulding, rubber over-moulding, sheet-metal forming and aluminium die-casting, to name a few.

HOW MUCH DRAWING IS INVOLVED?

At the early stage of a project, it is important to be able to get things right – and fast – so quick sketching is used to communicate or to nut out ideas. The product is modelled in CAD, prototypes are made, checked, adjusted in CAD and the process repeated until the result is satisfactory for tooling and mass production. Tim works closely with the part toolmaker to ensure high-quality finish of the produced part and that it matches the original design created in CAD.

WHAT DO YOU LIKE ABOUT YOUR JOB?

It's not the 'creating beautiful drawings' career he had envisioned as a student, when his desire was to be a 'front-end designer'. Now, however, he is far more interested in the nature of the work he actually does – solving problems and creating the tangible solutions that deliver a working product that can be held and appreciated by the customer. Getting to make 3D prototypes, solve complex mechanical problems, see first-hand manufacturing techniques and processes, and learn about the interesting capabilities of materials is very rewarding. In fact, he loves it!

Jacinta O'Leary spoke to Tim Garrow in November 2016.

Look at the Blackmagic Design website to see more of the company's work.

You can read more about the Red Dot Award won by Blackmagic at the Red Dot website.

Links to these websites are at http://nelsonpdtvce.nelsonnet.com.au.

PROFILE: ALESSI

Alessi is one of a group of Italian design factories that originated in 19th-century workshops north of Milan. Since the 1950s, Alessi has collaborated with famous Italian and international designers to create objects of beauty and interest – in contrast to most mass-production companies, which are concerned with whether a product is functional and easy to manufacture. Currently, Alessi has 12 Australian designers. This is the biggest group of non-Italian designers that contributes to the company's 'Italian design'.

In November 2015, company president Alberto Alessi visited Melbourne and gave a public talk at Federation Square. Some of the highlights of his talk follow.

Alessi is interested in qualities that are rare in industrial culture today, such as sensibility, intuition, and the desire to accept a bit more risk. Alberto Alessi described this risk by

Getty Images/AFP/Oliver Lang

Alberto Alessi

standing, almost rocking, on the edge of the platform he was speaking from. The front edge of the platform represented a line: the area on the platform, i.e. behind the line, was where all 'safe' products stood. The area below the platform, or in front of the line, was where all the 'outrageous' products stood. The products that Alessi is interested in are those that stand exactly where Alberto was, almost toppling off the platform, balancing artfully between 'safe' and 'risky'.

He explained the formula the company uses to make decisions on whether a product will be put into production: 'It's a mathematical model that we use once we have a well-done prototype. Not the first or the second prototype, but from the third one on.'

To create the formula, Alessi decided on four parameters important for a customer. They are: function, emotional connection, communication and price. It is the two central parameters that are most important to Alessi (see the central columns in the ALESSI formula table).

'The first central parameter is the degree to which people say, "Oh, what a beautiful object," and the relationship between the object and the individual. We call this SMI, which stands for sensation, memory, imagination. The second (CL) is how people use an object in order to communicate with other people. By this I mean *that objects have become the main channel through which we convey our values, status, and personality to others* – fashion is a typical case in point. Because people freely choose certain objects from the ones they come across, they tend to charge them with social meaning, as signs for communicating – in a visible, intelligible way – their distinguishing values. Objects can have status value or style value. By way of example, a gold Rolex watch is a status symbol, which suggests economic wealth, whereas a style symbol may be exemplified by an Aldo Rossi teapot, which reveals cultural sensitivity and familiarity with the architectural domain.'

Each parameter is scored out of five. If an item scores 18, Alessi knows it will sell 100 000 pieces a year. Low scorers are not put into production, no matter how much Alessi likes them. They are too risky. 'If you score three across each column, with a total of 12, it is not for Alessi,' he says.

Alessi has three categories of products: **Officina ALESSI** (exclusive design) – sophisticated expensive products and some limited productions, **ALESSI** – mass-produced quality products, medium–high price (the dream factory), **A di ALESSI** – more accessible, lower price products that are well designed (inclusive design).

9780170400336

Alessi formula for production units

SSS = F + SMI + CL + P

	F	SMI	CL	P
	Function (utilitarian value)	Sensoriality, Memory, Imagination	Communication, Language	Price (cost and price)
	It simplifies work (gadget) It is practical, functional, easy to use and to clean! It frees us from depending on others	It is pleasant to senses, creates emotion It has grip on memory, imagination and unconsciousness Creatively satisfying Very personal	It gives 'status' (ostentation) or 'STYLE' It is in trend It transmits culture It answers a need for self-representation (social needs) Very relational	Compared to similar products Related to quality Price expresses value ('rich' or 'poor' object)
1	PERVERSE Totally unserviceable, too complicated to use and to clean It doesn't work in fundamental parts (serious and plebiscitary rage?)	UNPLEASANT/ REPELLING It smells, hurts senses It recalls bad memories or emotions I don't like to feel (fear, anxiety, repulsion ...)	OUT Obsolete (kitsch) It promises a difficult relationship	VERY (too) EXPENSIVE It's out of any logic!
1.5				
2	QUESTIONABLE/ ARBITRARY Not very useful, or not very functional Complicated to use and clean It doesn't work in non-fundamental parts (light and subjective rage ...)	AMBIGUOUS/ NOT VERY NICE/ UNATTRACTIVE It sharpens a bit, but not in a convincing way ... Maybe it troubles me ...	DOUBTFUL Not obviously out, but doubtful It weakly expresses a concept or a formal synthesis	EXPENSIVE I suspect I'm paying more than what I buy ...
2.5				
3	STANDARD Utility, use, cleanability, working in conformity with the average of the typology	NEUTRAL Fail, imprecise, dull It has no memory It doesn't sharpen in half	ACCEPTABLE Without any negative or positive features with respect to the parameter	IN LINE/REASONABLE/ COMPARABLE It's in line with prices on the market (or with the prices of the manufacturer)
3.5				
4	Very practical and functional Very useful, not complicated and easy to use and clean	ATTRACTIVE Pleasant, seducing, sharpening	IN It is trendy, updated, fashionable It has a recognisable and immediate language	INEXPENSIVE/ PROFITABLE I believe I buy more than what I pay for
4.5				
5	BRILLIANT Really useful, very easy to use and clean It is a great idea!	EXCITING It strikes, it is a tonic!	ILLUMINATING It makes innovation on existing trends but in a positive way (progressive, initiatory) Maybe it is a classic (cult object)	I BUY 2! It looks so convenient that I buy two!

Table supplied with kind permission from Alessi by Gloria Barcellini, Assistant Metaproject, Alessi, Italy

9780170400336

CASE STUDY

Jim Hannon-Tan: product designer

WHAT LED YOU TO THIS POINT?

Jim Hannon-Tan is one of the few Australians who has designed for Alessi. He studied Industrial Design at RMIT in Melbourne. After years in Europe and a multitude of collaborations, commissions and studio experiences, he came full circle back to Australia in 2016 to set up a studio.

Photo by Valentina Zanobelli

Jim Hannon-Tan

WHY DID YOU LEAVE AUSTRALIA?

As a young design student, Jim thought the Australian outlook on design, for the most part, was rather jaded, boring and uninspiring; he couldn't foresee choosing one product area and building a designing life around that. At RMIT University he was greatly inspired by his professor, Kjell Grant, who talked of his experiences as an international designer, and illuminated what was going on in design internationally. Jim was determined to be a part of that world. Recalling a principle from *The Art of War* by Sun Tzu – that if you cut off the easy retreat, then you will succeed, i.e. if there is no easy way out, there is little choice but to persevere despite all adversity – in 2001 he bought a one-way ticket to Italy. He figured this would force him to stay, to learn the language and to become immersed in the culture.

He has always believed that, as a designer, it is important to travel and move to see how people live in different cultures; it allows one to make fresh observations of human behaviour.

WHAT WAS YOUR EXPERIENCE IN EUROPE?

When Jim first arrived in Italy he took a job teaching English but was always looking forward, being curious, asking questions, doing research, aiming to be in the right place at the right time to get a foothold in his chosen career. After three months he got his first break, which opened up the world of design.

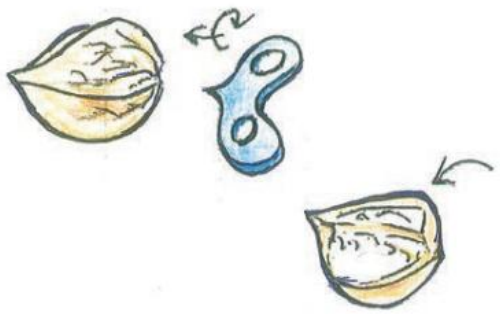
HOW DID YOU GET TO WORK WITH ALESSI?

Through his increasing network, he met Laura Polinoro, who ran Alessi workshops on Lake Como, and by this point his Italian was good enough to participate. From the workshop he developed a concept for a nut-splitter. The functionality was inspired after watching an Italian friend open a walnut with a knife. The form was inspired by the helicopter-like seeds from maple trees. Alessi liked it, picked it up and developed it. They created several prototypes that were 3D printed at a dentist's surgery in Padua (3D printing was a very new technology at the time), tested it out and put it into production. Although Alessi retains much of its manufacturing in Italy, the nut-splitter was produced in China. It was made using the **investment casting** process (the same way

investment casting the pattern or shape is 'invested' (surrounded) by a suitable material, which forms the cast

Photo by Gabriel Heusser

Inspiration from watching a walnut being split with a knife and maple tree seeds



Jim Hannon-Tan

Drawings for the *Nutsplitter*

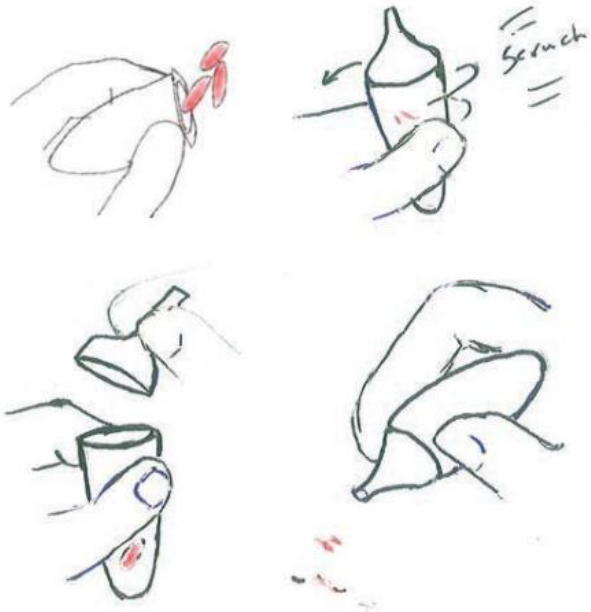
9780170400336

Photo by Cameron Snelgar

The Alessi *Nutsplitter*

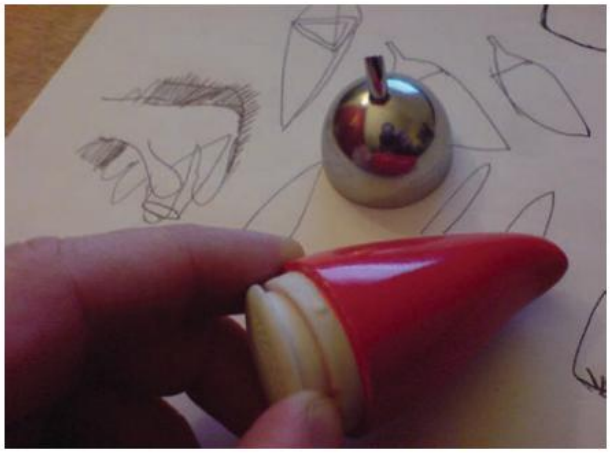
jewellery rings are made). Named *Nutsplitter*, it was the first Hannon-Tan product for Alessi.

His second Alessi product was inspired by Italian cooking. Italians like to sprinkle crushed chilli on dishes such as pasta amatriciana but, after handling the chilli, residue remains on the fingertips and it tends to burn. The initial design proposal was followed by the design development phase, during which Alessi developed several functional prototypes. One day Jim visited the factory for a design review, for which several prototypes had been prepared. A bag of chillies was brought out to enable them to test all the prototypes together. About five minutes into the trial, chilli flakes were everywhere; the meeting disintegrated into chaos as all the participants began to feel the effects of the



Jim Hannon-Tan

Piccantino drawings



Jim Hannon-Tan

Checking the designs

Alessandro Milani

Piccantino

chilli, and began sneezing, crying, or just evacuated the room. A truly immersive experience from the users' point of view that demonstrated the validity of the product. This beautiful red chilli-shaped product, which evoked the form of the Neapolitan (from Naples) good luck charm, was also shaped like a chilli. It was named *Piccantino* and was Jim's second product for Alessi.

9780170400336

WHAT SEPARATES THE EUROPEAN APPROACH FROM THE AUSTRALIAN?

Between 2001 and 2010 (over eight years) working in design studios in Milan, Jim learnt so much about the Italian approach to design. Firstly, that aesthetics and quality are of prime importance. This multidisciplinary, artisanal approach relates through an unbroken lineage from the contemporary studios of Milan back to the workshops of Renaissance times. Italian designers see their role within a cultural context. This is in contrast to the Australian scene, where products are shaped by 'brutal functionality'. They are often born of necessity or invented to solve a functional problem, with aesthetics viewed as superfluous and beyond the commercial need. This pragmatic design approach also results in a certain inventiveness and ingenuity, which can be a different kind of advantage for Australian designers in a rapidly changing and ever more interconnected world.

In later years, Jim's career included spells for Marcel Wanders in the Netherlands and Tom Dixon in Britain, working for a wide range of international clients. These countries also have their own approach to design. At the Dutch studio of Marcel Wanders, there was an artistic approach in which 'dreams' were manifest to create unique products. At Tom Dixon there was an emphasis on industrial processes and an obsession with materials.

HOW MANY PROJECTS ARE YOU WORKING ON AT THE MOMENT?

At the moment Jim has a range of clients. The projects include:

- technology products for a New York–based client
- a mixing appliance for a beverage start-up in London
- a homewares collection for a Melbourne start-up
- modernising the product range for a staircase factory in Adelaide
- homewares for Ikea
- new design proposals for Italian companies.

He has several other major projects in the wings but, as some require work up front for future royalties, they can sometimes get less urgent attention. He also has 1000 little projects waiting; accumulated in sketchbooks and Evernote (software) – ideas of his own and suggestions from others.

WHAT DOES A TYPICAL WEEK INVOLVE?

Due to the collaborations with the northern hemisphere, the workday can spread due to time differences and the need to catch people at crucial times.

'I will skype with New York early in the morning, London or Europe in the early evening. Technology is good for supporting international relationships but is far from replacing face to face.'

Jim still likes to travel internationally several times a year to meet with clients, visit factories and seek inspiration.

He will typically try and focus on a single project per day, with clear deliverables. Activities involve planning, design research, sketching, 3D modelling, 3D printing ('used for rapid evaluation – we have two Upbox 3D printers in the studio'), design and product sample reviews, and factory visits when possible.

'It is critical to know the processes, materials and, most importantly, people with whom you are working.'

Jim does a lot more sketching now as it is important (and faster) to work things out quickly before developing the digital version. He has a favourite notebook – unlined, landscape A5 with a soft moleskin cover. He is very fast at CAD modelling but it means a lot of time on the computer.

'I'm trying to cut back, to avoid being a "CAD monkey", which young designers sometimes can feel like … plus the computer is only a tool. I believe in getting out from behind the computer and going outside into the world; for observation, discussions, sketching, making, etc. … all important for inspiration.'

WHAT IS THE ROLE OF A DESIGN BRIEF IN YOUR WORK?

When being commissioned, the market research or any necessary data has already been done by the clients and is built into the brief. However, the closer you are to a design company, the more input you have into the design brief. To write the brief is to define the parameters of the design problem, which is half the work.

Through all his experience (in-house, freelance, commissions, partnerships, etc.) he knows now that a designer is not limited by what exists.

'Originally I thought that an industrial designer should skilfully exploit the constraints of a process, but I reached the limits to this thinking when a

9780170400336

manufacturer told me that 'anything is industrialisable'. Since then I have realised the role of imagination, which perhaps is the difference between a designer and an engineer. Sometimes the design should synthesise a solution within the parameters of the problem; other times, the designer should redefine the scope by thinking beyond the constraints. For this reason, it is important for designers to be close to the design making decisions within a company.'

INTELLECTUAL PROPERTY

Registering designs was a part of Jim's role at Tom Dixon and, while it is important to be diligent, it is not something that is easily enforceable. Often it is better to focus on creating new things, and to be discreet about ideas, contracts and projects until they are ready for sale.

SUSTAINABILITY

Jim always looks for an integral element of sustainability in his designs, but this also needs to be addressed on a systemic level. Some of his independent products have incorporated the theme of sustainability.

Clampleg (2001) is a table leg with a clamp-like top, designed to work as a set to convert any flat surface into a table. As a set they are cleverly designed, adaptable, durable and have an aesthetic that would make any owner proud to store them in a visible way.

Jim Hannon-Tan

Clampleg

Nesting Table (2010) is a set of three tables, cut from a single block of marble to reduce waste; it is really a piece of design art, a statement. While it was originally made for an exhibition at the Salone del Mobile in Milan, Italy, in 2010, the Milanese gallery L'eclettico later put it into production.

Cutting Up Knives (2007) was a project with others for Salone Satellite – an annual design event in Milan. One hundred selected knives were water-jet cut and repurposed into bottle openers.

Jim Hannon-Tan

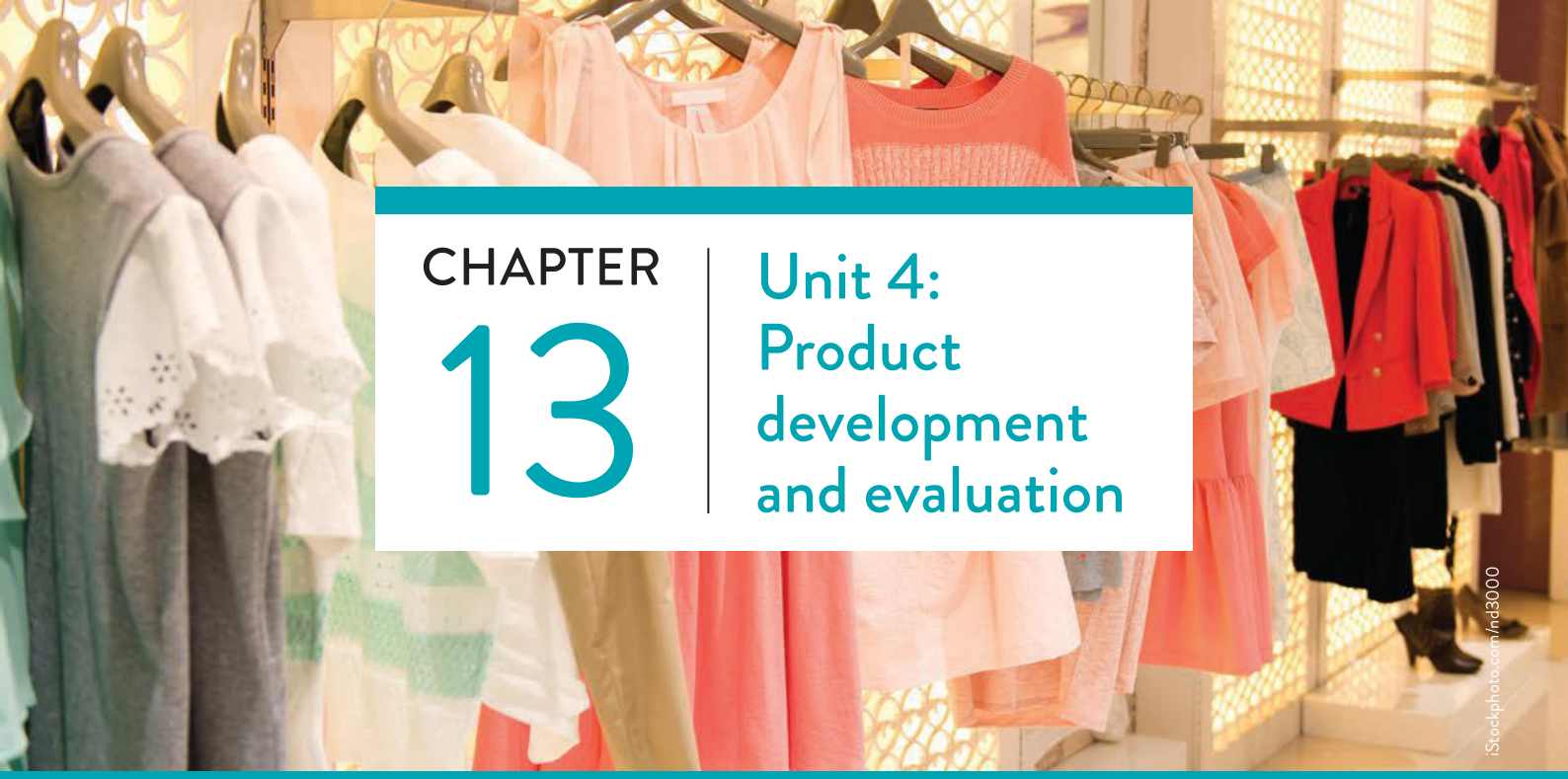
Cutting up knives

WHAT'S NEXT?

'The great experiment is to see if I can run a cutting edge international design studio from Australia, which I think is possible in these days of easy global connections.'

Jim Hannon-Tan spoke to Jacinta O'Leary in January 2017.

You can read more about Jim Hannon-Tan and see more of his designs at his website or the Alessi website. Links to these websites have been provided at http://nelsonpdtvce.nelsonnet.com.au.



CHAPTER 13

Unit 4: Product development and evaluation

iStockphoto.com/rd3000

CHAPTER FOCUS

In this chapter you will learn about:

Area of Study 1: Product analysis and comparison

- How we choose products p. 377
- Defining product attributes – function, user-considered, ergonomics, safety, cost/value, aesthetics, environmental/ social/economic and quality p. 378
- Prioritising product attributes p. 382
- How products are evaluated p. 384
- Comparing products p. 386

HOW WE CHOOSE PRODUCTS

People choose products for many different reasons. As a consumer purchasing a product, you are making an evaluation of that product. In an unconscious way, your mind has a checklist of what you are looking for, and this will reflect your values. Sometimes this relates purely to the function of the product – what you expect it to do and the price you are prepared to pay. Your parents may favour products that are rare or of good quality from their younger years, or they may only be interested in the sustainability of a product. Your friends might only be interested in buying clothes of certain materials. In other situations, you and others will be swayed by the appearance of a product.

Your choice depends entirely on what you value and upon your own situation, e.g.:

- your budget
- your experience with this type of product
- what you expect it to do and how long you expect the product to last (relates to quality)
- how important the appearance of the product is to the situation
- your interest in sustainable products
- your knowledge of the materials that the product is made from
- peer pressure (what your friends will think).

9780170400336

In real life

Assume you want to buy some winter socks. These are some of the thoughts and reasons you might use to make a decision about which socks to buy:

> I get very cold feet, so I am looking for socks made of wool, or mostly wool. They need to be thick, but not so thick that they make my shoes feel tight. They need to be quite long, around mid-calf, and I don't want the elastic around the top to be too tight because this irritates me after a while. I also like bright but strong colours. I want the socks to be machine washable and of a quality that will last for a few winter seasons. I am prepared to pay up to $15 but no more.

Shutterstock.com/Nagy-Bagoly Arpad

While you are shopping for socks you will be relying on:

- your experience of the product (tight elastic irritates you)
- your knowledge of the materials (you know wool to have insulating properties and to be warmer than other fibres)
- the quality you are looking for (you expect the socks to last a few seasons)
- the appearance of the socks (you prefer bright, strong colours)
- your budget.

In this case, peer pressure is a low priority for you as you are more concerned with the functional value of having warm feet. Using these focused requirements (criteria) can help you to:

- make informed decisions
- prioritise your needs and get what you want.

By isolating the important **attributes**, you are able to select the exact product that suits your needs.

attributes features of something that make up its whole; characteristics and qualities

DEFINING PRODUCT ATTRIBUTES

In any situation where products are analysed and evaluated, the first thing that consumers, designers and manufacturers need to do is define the attributes – or features – that the product should or could have, just as the consumer has decided on the attributes or features of the socks they need and want in the situation above. Note that the distinction between 'need' and 'want' is important, as it helps prioritise what is essential.

The attributes or features of a product can be defined by the product design factors.

Different attributes of a product include:

- its primary function, and the secondary functions that add to or enhance it
- how it performs or operates (functions), its reliability and quality
- its user-friendliness or how it suits the user's need, ergonomic and safety features
- whether it is innovative – a really new type of product
- how it appeals to the user visually, tactilely (to touch) and aesthetically, etc.
- the materials used and how suitable they are for the target market (or end-user)
- its environmental, social and economic impacts
- its cost/value, timing on the market
- the quality of its construction.

Many of the attributes/features of a product are defined as product design factors in more detail in Chapter 4.

Soft and hard attributes

The attributes of a product are sometimes categorised as soft – relating to the subjective, more aesthetic, perception-based and philosophical aspects of design – and hard, or relating to the functional, utilitarian and measurable aspects of design.

FACTORS AS ATTRIBUTES

Purpose, function and context

Products have primary and secondary functions:

- Primary functions relate to the main purpose of the product – what it should do at a basic level.
- Secondary functions support the primary function; they are what separate different products with the same primary function, making them suitable for different end-users.

Let's take a product such as a lemon squeezer as an example. Its purpose or major function is to squeeze juice from citrus fruits. Yet so many different lemon squeezers perform differently; they have a different set of secondary functions.

Take a look at these three lemon squeezers and then decide which squeezer the list of secondary functions apply to.

Shutterstock.com/Jiri Hera

A lemon squeezer with an in-built tray

Shutterstock.com/Stephen VanHorn

A manual lemon juicer, an example of the 'press' design

Shutterstock.com/Evgeny Karandaev

A wooden lemon juicer

- Collect the juice (the shape and depth of the container).
- Sit stably on the bench, with minimal slipping (the material on the underside).
- Extract juice effectively and avoid hitting the user's knuckles (the size, shape and spacing of the furrows).
- Pour effectively (the shape and placement of the spout).
- Be hygienic and easy to clean (the materials it is made from).

When choosing any product you will be thinking about the context (the situation where it is used and who will be using it) and choose the product with the secondary functions that are suitable. Secondary functions could be considered hard attributes. These will affect its operation and performance, i.e. what you expect the product to do when you use it. Some consumers value these functional aspects of a product above all other attributes. They are unconcerned with its aesthetics, are prepared to pay a high price and don't mind what materials the product is made from. They prioritise function!

To revise primary and secondary functions and functionality, go to page 92. Other parameters to consider are reliability and quality, which also overlap some of the other factors that follow.

User-considered design

It helps if the design of the product has considered the needs of the user (the designer has used the user-centred approach) and the product is easy to use or user-friendly. This means that the user won't feel strained or be in danger of having an accident, or of not achieving the task for which the product was intended.

The product should function in a predictable and conventional way. Some kitchen products are designed to be used by people with arthritic hands, therefore the handles are large. Most furniture is designed ergonomically with the use of anthropometric data so that it is comfortable and suits human movement (see below).

User-friendliness of electronic devices is helped by the communication used on and with the product, such as using identifiable shapes, colour-coding (e.g. red = hot, blue = cold), and clear symbols and markings. Standardised symbols assist with clear communication. These can be found in a variety of Australian Standards, depending on the type of product or system.

Ergonomics

Ergonomics is how well a product's many functions are suited to its use by the human body. Ergonomic principles are generally concerned with comfort, ease of use and minimising strain, injury or fatigue. For example, for a **cabinet**, ergonomics might relate to:

- the height of the cabinet
- the ease of use of the drawers and doors
- the shape and placement of the handles
- the weight of the entire unit if it is to be shifted.

Ergonomics is not normally applied to clothing, but for a **dress**, the user is considered by:

- the ease of putting on the dress
- how it fits the body without squeezing and pinching
- the placement and tag of the zip
- the size and shape of buttons
- the tightness of sleeves, etc.

The designer considers how the garment fits the user's body, and how the body moves and interacts with the garment. It is particularly important in sports clothing. *For more information on ergonomics and other relevant aspects of product design, go to page 101.*

iStockphoto.com/NuStock

There are many ergonomic factors to be considered in the design of an industrial mop and bucket

Safety

Safety is an important factor when evaluating products, particularly products for users who are in some way vulnerable, e.g. children, those with a disability and the elderly. Safety relates to the way the product is used and how it performs its function: does it pose any obvious or hidden risks to the user? Indirectly, a product may affect other people even if they are not the user, and their safety must also be considered. Some of these safety elements are governed by Australian Standards. *Go to page 112 for information on Australian Standards.*

Safety can relate to something simple, such as squashing a finger when using an implement or closing a drawer; or something major, such as the need for a fence around a pool to reduce the danger of drowning. Hence ergonomics and regulations both play a role in safety.

9780170400336

Cost/value

There is a balance between the quality of the product and the cost. Some consumers are willing to sacrifice quality for a cheaper price if they feel they are getting value for money or if the purpose is short-lived (e.g. a cheap hammer for a short-term project). Others are prepared to pay the cost to obtain high quality and a long life (e.g. a more expensive hammer for a busy tradesperson). Some customers feel they are getting value for money if they can see the product's worth in the materials and the way it has been made. Others are willing to pay a higher price because they perceive abstract things of value in the product, such as the soft attributes of prestige, brand, reputation, fashion, etc. All of these are attributes that different people will value to different degrees and be prepared to pay for according to what they value. Cost might be considered a positive attribute of a product if the consumer thinks it is good value. *Go to page 107 for more information on cost.*

Visual, tactile and aesthetics

Aesthetics is about how we see beauty in things we understand through all our senses – sight, hearing, touch, smell and taste. It relates to the features of a design that give it its appearance and feel (e.g. shape, line, size, proportions, colour, material composition and texture) and sometimes its smell and its sound. Taste of course is related to food.

Aesthetics depends on the viewer and their knowledge, culture, likes and dislikes. Some consumers value the beautiful appearance of a product above all else. It is their major priority and a product's aesthetics are more important to them than its function, materials, sustainability or quality. They are prepared to pay for something they love the look of.

For many of the products we assess, we respond firstly to what we see. When considering appearance, the following elements and principles need to be discussed. *For a detailed discussion of the design elements, go to Chapter 3; to revise product aesthetics, go to Chapter 4.*

What design aesthetics are made up of

Elements		Principles	
Line	Point	Balance (Visual 'weight')	Contrast
Shape	Tone	Rhythm, movement	Proportion
Form	Transparency	Symmetry/asymmetry	Pattern
Colour	Translucency	Positive or negative space (void)	Repetition
Texture, feel	Opacity	Surface qualities	
Subtleties			
Markings, figuring		Decorative detail, patterning	
Reflection, sheen		Use of words, lettering style	
Brand marking, symbols		Simplicity/complexity (clean/busy)	
Uniformity/random changes		Natural/synthetic	

Sustainability

The **environmental**, **social** and **economic impact** of a product may affect its value to a potential consumer or user. Increasingly, consumers are critical of how products perform in these areas. They look for evidence of:

- design strategies that have been used to reduce the environmental impact of the product
- supply chain of materials, parts, manufacturing and distribution
- social and economic benefits to which the product and manufacturer contribute. Are the workers treated well and paid fairly? Does the product itself benefit the user in terms of their health or connectedness in society?

Carefully read through the environmental design strategies and social measures that are listed on page 124 – specific strategies are given for particular product types.

Quality

Quality relates to how well the product suits its purpose; how long it can satisfy the needs and wants of the user. This can be in terms of both function (durability and reliability) and aesthetics. Quality in a product depends on:

- the properties and characteristics of the materials used, and their suitability for a particular product or situation
- the product's ability to perform its function and to do so repeatedly and well
- the strength and accuracy of construction and joining methods
- the quality of the components used and how they are attached (or designed into the product)
- the level of design (consideration of the user) and design aesthetics
- the expected life of the product.

Go to page 94 for more information on quality.

All of the above factors are important considerations for those users/owners who value and prioritise quality, reliability and good value in a product.

Many reputable companies back up the stated quality of their products with assurances, warranties or superior service whenever there are problems. This tends to instil a feeling of confidence in the customer that the product is 'worth' paying for!

Some of the consequences of poor quality are:

- an increase in waste as products are replaced more frequently
- customer frustration and loss of brand loyalty
- possible danger to product users
- loss of company reputation
- an increase in costs for the manufacturer if required to replace or recall.

PRIORITISING PRODUCT ATTRIBUTES

The importance of the different product attributes changes, depending on:

- **the product type**. For some types of products, function and quality are critical and are what the product is judged by. For others, the aesthetics or look of the product is of a higher priority
- **the user**. What you want from a product will depend on what sort of person you are. The needs and desires of the user change depending on their background, income or willingness to spend, values, tastes and life stage.

prioritise
put in order of importance, or give something preference because of its importance

User, manufacturer or designer?

The **prioritising** of attributes also changes depending on who you are – manufacturer, designer or user – and your **values**.

Using our original sock example on page 378, the user's needs are listed – they are looking for comfort, safety (good circulation), durability, good value and a specific appearance. They might also value the use of sustainable materials (organic wool, natural dyes). The user might value the

first three attributes more than the last two, which means that these first three are the 'must haves'. So if the user found naturally dyed woollen socks that were comfortable, had loose elastic and were durable, they might compromise on the attributes of good value, colour and the use of sustainable materials (and perhaps be willing to spend a bit more, or be satisfied with a less attractive sock).

iStockphoto.com/dorioconnell

A user might be prepared to compromise on the appearance of their new socks

For the manufacturer, their priorities might be that the sock is cheap to make and gives a high profit margin; that it wears well, but not too well (i.e. that it retains a perception of brand reliability, but also needs to be replaced regularly), and that its design incorporates a recognisable brand mark. Other sock manufacturers will stake their reputation on good-quality products only, i.e. they will ask a designer to design a sock that functions really well, uses high-quality wool, applies new technologies and is aesthetically creative.

It is possible to generalise by saying the following:

- Users want products that:
  - function very well, and fully satisfy their needs
  - match their idea of what looks good (their aesthetics)
  - last well
  - represent good value
  - incorporate the latest technology as improvement
- Manufacturers want products that:
  - function well
  - create a profit
  - are efficient to make
  - create and retain brand credibility and style
  - become very popular.

It is the designer's role to recognise these different and sometimes conflicting priorities, and seek to balance and satisfy them as best they can. Products that are successfully designed achieve that balance between the needs of the customer and the needs of the manufacturer and retailer.

Values vary and change

The importance of a product's attributes or features may change depending on how 'old' a product is (i.e. how long it has been on the market or how long the user has owned it), and the value of this product to both users and manufacturers may also change.

Products that are 'new'

When a product is introduced, the user values products that:

- perform and function at a higher level than alternatives
- have unique or original aesthetic features
- are innovative.

These are the attributes that the user prioritises. Because the product is new, the user usually has a higher level of emotional attachment to it.

The manufacturer might value a new product that has attention-grabbing features that will capture the market, and that can be sold at a price that will recoup their development costs.

Products that have been around for a while

As the product becomes more established, users expect it to:

- be reliable and function well
- have a 'safe' appearance
- be of reasonable value.

As the product loses its 'newness' and novelty, the user becomes less emotionally attached to it. If a product breaks frequently or is unreliable, they will become frustrated and consider replacing it. On the other hand, some owners cherish old and reliable products that still look good and are unavailable for purchase by others.

At this stage in a product's commercial life, the manufacturer values products that sell consistently and have broad appeal. They are usually products of reputable quality.

'Older' products

When a product has been on the market for a long time, users expect it to:

- cost less than the alternatives (to be good value)
- function reliably
- have a more conservative appearance
- include features that are tested by time, but are not really innovative.

As the style of the product ages and the functions become obsolete, the user usually loses emotional attachment to the product, and looks for a newer alternative.

At this stage, the manufacturer has probably developed a newer version of the product and is unwilling to support the older one (either through warranties, servicing or repair, and the replacement of parts).

Products may have value for reasons other than their 'newness'. They may have:

- symbolic, emotional or sentimental value
- antique value
- social value
- brand value
- cultural, religious or political value.

HOW PRODUCTS ARE EVALUATED

Products can be assessed and evaluated using a wide variety of methods and tools. Some methods provide **qualitative information** and others provide **quantitative information**:

qualitative information based on experiences, descriptive feedback

quantitative information based on numerical data and easily represented in charts and graphs

- **qualitative** – descriptive information about experiences or stories, usually sourced from individuals or small groups; provides complex data that is hard to classify, but provides a detailed picture; the information is usually subjective. It is usually written statements that take a long time to interpret for the purpose of identifying and evaluating trends.
- **quantitative** – numerical information sourced from a large number of people; simple data that is easy to classify and useful for generalising trends; it is measurable, objective and can be tested. Quantitative data can be easily presented in graphs and charts.

Methods of evaluating products that provide quantitative or qualitative information, or both, include:

- comparing specifications (things that can be measured or judged physically)
- user trials and testing (with feedback surveys or questionnaires)
- research of users (market research; sales and returns)
- expert appraisal (trials and destruction testing; certification).

9780170400336

Comparing specifications (usually quantitative)

The simplest way of comparing products is by their specifications, e.g. comparing:

- size, weight, etc.
- materials
- functions available
- capacity
- energy and/or water usage
- cost.

The particular aspects that will be compared will depend on the common requirements and features for the type of product. Most of this information is usually quantitative in nature. However, the fact that something is larger or has a bigger capacity doesn't necessarily mean it is more suitable for every end-user in every context.

Other than by comparing measurable specifications, one way to get quantitative information about products is to score attributes or criteria out of 10 for suitability.

Market research (qualitative or quantitative)

Market research is done through interviews, focus groups, user trials, questionnaires and surveys. The information obtained is used not only to evaluate the users' perceptions of existing products, but also to indicate the desired direction of new products. Depending on the nature of what is being asked, the resulting information can be quantitative (numerical) or qualitative (descriptive). *To find out more about market research, go to page 389.*

Sales and returns (quantitative)

Manufacturers carefully assess sales over a product's sales life (from when it is first introduced to the market, through its high-profit period, to its gradual decline in sales), and there are different expectations of sales at each stage. If a product doesn't perform or sell as expected, manufacturers start asking serious questions about the design, suitability and marketing of the product.

Manufacturers keep track of sales through barcodes and stock inventories. They also keep careful track of product returns, particularly through their warranty systems. If a specific type of product is returned frequently, this indicates that there is a problem somewhere in the design, quality and/or manufacture of the product. If the product has to be replaced or serviced frequently, this increases the cost of that product to the manufacturer.

User trials and testing (qualitative and quantitative)

User trials involve a range of typical users testing and rating particular products using standard tests, based on the typical way the products are used.

A group of users are given a range of criteria, and they test and rate products according to those criteria over a period of time. The tests by Choice – a consumer organisation – are the best example of this type of testing, so it's a good idea to have a look at the reports Choice publishes on products (either at your local library, or on the Choice website – some reports are available without a subscription).

The Choice website is a great place to research user trials and testing. There is a link provided at http://nelsonpdtvce.nelsonnet.com.au.

Products are also compared according to the design features each product offers (e.g. physical size, size of engine, warranty length, options available, functionality, cost, energy ratings). The criteria listed differ depending on the product type and the needs of the users. User trials are particularly useful for products with a known safety factor to make certain they are safe under many conditions.

Link via http://nelsonpdtvce.nelsonnet.com.au to a fun take on IKEA testing. For videos of real IKEA tests, put the term into a search engine.

For good examples of a manufacturer carrying out product testing, follow the link to the James Dyson Foundation.

9780170400336

False or unrecognised labels

Be wary of certificates and labelling that you don't know of, or that are not officially recognised. Many companies try to give their product credibility in areas that can't be proved by creating their own label or using labelling systems that require only a low level of proof. In the environmental area this is called 'greenwashing' – giving the product the appearance of being environmentally responsible. *To revise greenwashing, go to page 127.*

Certification

There is an enormous number of both International and Australian Standards that are used to test and determine whether products perform in the way we expect them to, and meet a minimum standard.

Once tested and certified, products can be labelled with the 'five ticks' StandardsMark™. This shows that the products comply with the relevant standard and all its requirements and regulations. *To revise International and Australian Standards, go to page 112.*

The StandardsMark™ on the inside of a bicycle helmet

Products can carry other forms of certification that cover quality or environmental and social concerns. Such certification means that the products, the materials they are made from or the manufacturer's systems have been assessed and meet recognised standards. This provides evidence that these products are 'good' in those areas, and can be used as a basis for making comparisons with other products. *To revise these and other environmental and socially responsible certifications, go to pages 130–1.*

Certifications include:

- **ISO 14000** – International Standards for environmentally responsible manufacturing systems and products
- **ISO 9000** – International Standards for quality processes and practices
- **FSC** – Forest Stewardship Council certification for the environmental, ethical and socially responsible management of forests
- **Fairtrade** – for materials and products that are sourced in socially responsible ways
- **AFRDI Green Tick** – certifying sustainable furniture designed and made in Australia and New Zealand.

COMPARING PRODUCTS

In this Area of Study, you will be asked to compare, analyse and evaluate similar commercial products. To compare products effectively, it is helpful to begin with set criteria. The criteria need to be based on:

- the context
- the user
- the user's requirements
- the attributes of this product type that would suit their needs.

Use the product design factors to assist you in creating the criteria.

9780170400336

Start by defining your end-user and the context and write criteria to identify and assess:

- the **primary function** or purpose, and the specific needs of the specified user and the context in which they will use this type of product
- **aesthetics** – the look and the feel that will appeal to the target market or specific end-user
- **quality** – list the specific quality indicators such as material, construction, components and level of design expected by this user
- **price** – what would be value for money?
- **sustainability** – think about environmental, social and economic issues that interest the user and that might relate to:
  - stages of the product's life (e.g. materials sourcing, production, transportation)
  - the supply chain and treatment of workers and communities
  - whether the product provides a social benefit, such as connecting with others or improving one's health.

Only create criteria for relevant factors. In this Area of Study they can be written as questions (e.g. Does it have ...?) or statements (e.g. It must be ...).

Using criteria for testing and comparing

In industry, products are tested against, or compared with, similar products using a variety of methods. You can adapt some of these methods to provide you with feedback, observations and data for your analysis and judgements, e.g.:

- comparing and testing **product specifications** (sizes, shapes, capacity, etc.)
- **visual checking** – observation and comparison
- **trialling** the product in controlled situations (where you manage the conditions and each test is the same) or in real-life situations
- **group discussions** – similar to a focus group, where the products and how they might be used are discussed and opinions are shared
- **questionnaires** – writing questions about the products for other people to answer (some will ask 'users' to score an attribute out of 10 for quantitative data and some will ask their reaction or feeling about the product for qualitative data)
- **research** – finding out information about certification; materials; and environmental, social and economic issues.

When you compare and evaluate the products according to the criteria you have developed, make sure you use both qualitative and quantitative methods of checking and testing. You can set up a table with a star rating system (quantitative) for each criteria but also with room for statements (qualitative).

To compare products against the criteria you have developed, you need to make judgements about how each of the products satisfy the criteria. You need to have evidence or reasoning to inform and support your judgements.

Most conclusions can be made by a visual comparison of the products, but important information to have for a comparison would include:

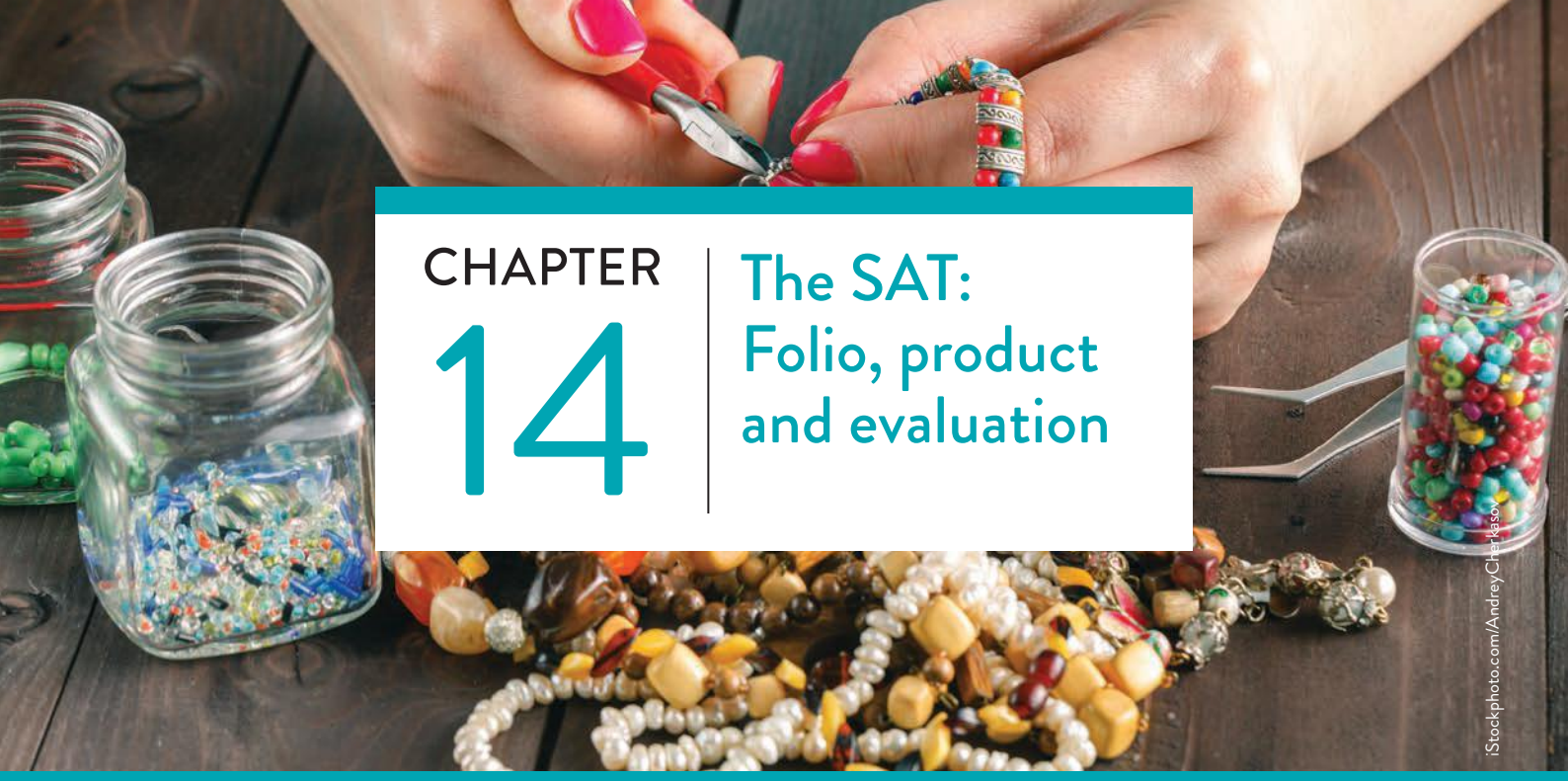
- information that allows you to judge each product's quality
- relevant specifications such as size and capacity
- the price
- the materials, where the product was made, etc.

9780170400336

An example of using criteria to compare lemon squeezers

Criteria for comparison for my grandma (end-user)	Lemon squeezer 1	Lemon squeezer 2	Lemon squeezer 3
Purpose, function and context Must suit my grandma's arthritis (she lives alone and doesn't want to ask for help) Must be of excellent quality – long lasting	It kept slipping when she used it 1/5	OK 3/5	OK 3/5
User-centred design Must suit grandma's hand size and be easy to use with not much pressure needed	3/5	Required too much pressure to use 2/5	She couldn't hold it properly 1/5
Innovation and creativity Not important, but if it helps grandma – yes	3/5	3/5	3/5
Visual, tactile and aesthetics Be brightly coloured and have a non-slip texture	Yes, both 5/5	3/5	Not colourful 2/5
Sustainability Grandma prefers sustainable products so would prefer a good-quality one made locally	Not plastic 2/5	Looks strong 3/5	Looks unbreakable 5/5
Economics She doesn't mind paying for quality – she will pay up to $20	When comparing products, you will need to know their retail price		
Legal responsibilities Not relevant to grandma but the product must be safe for her			
Materials She prefers sustainable materials, but they must also be hygienic, washable and non-breakable	Not plastic 2/5	Metal and strong 4/5	She loves wood and it's hygienic 5/5
Technologies It must be made to quality	Plastic breaks 2/5	5/5	5/5

9780170400336



CHAPTER 14 The SAT: Folio, product and evaluation

iStockphoto.com/AndreyCherkasov

CHAPTER FOCUS

In this chapter you will learn about:

- The product design process and the product design factors p. 389
- An overview of the SAT:
  - Unit 3, Area of Study 3: Designing for others – creating a folio p. 390
  - Unit 4, Area of Study 2: Product manufacture – making the product and documenting progress p. 405
  - Unit 4, Area of Study 3: Product evaluation – analysing your finished product p. 409.

The product design process

The product design process covers the process and activities that lead to great solutions for design problems and is central to all your work in Units 3 and 4. In Areas of Study 1 and 2 of Unit 3, you will learn how versions of the product design process are used by designers working solo and how those in bigger companies use it. In particular, you will use the product design process yourself in your major project – the SAT, which is completed in Units 3 and 4. Your folio will document how you have worked through this process. *To revise the product design process, go to Chapter 2.*

The product design factors

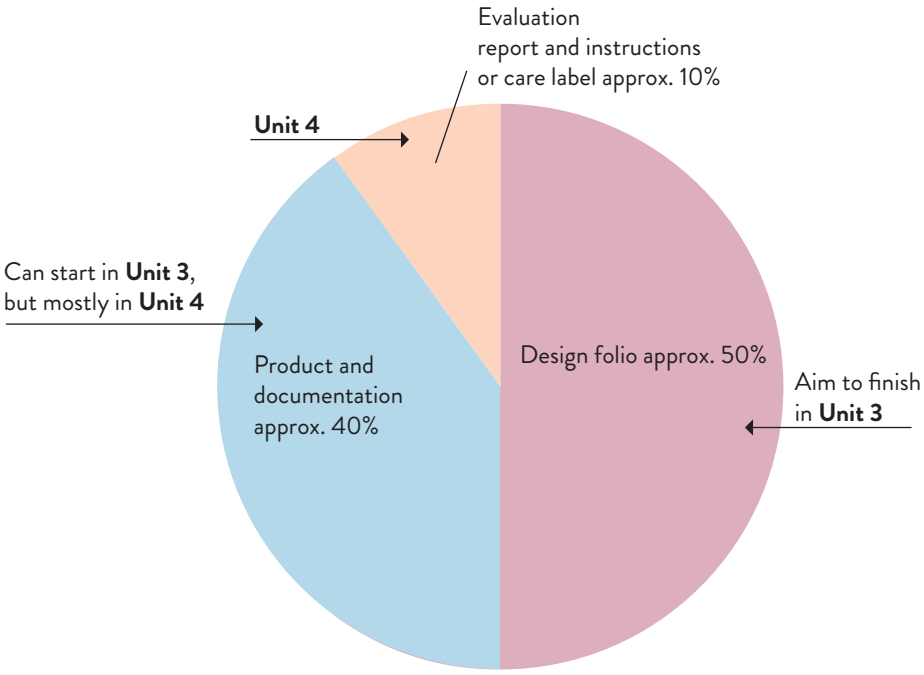
The product design factors are the influencing factors you will address as you work through the design process. In Units 3 and 4 you will be referring to and dealing with the product design factors throughout your folio work for the SAT, particularly when writing your design brief. You will also use it when analysing products in the commercial arena in other areas of study in both units. *To revise the product design factors, go to Chapter 4. To see how the product design factors might apply to the design of a bag, go to page 248.*

9780170400336

AN OVERVIEW OF THE SAT

There are three outcomes related to the SAT:

1 **Design folio** – researching, designing and planning a solution to your design brief (completed in Unit 3)
2 **Product and documentation** –starting the manufacture of your product in Unit 3, and completing production in Unit 4. Following your plans; managing materials, tools and processes; and recording your progress (in a journal or log with text and photos) and any modifications. Also adding to, refining and finalising aspects of your design folio
3 **Evaluation report and care/user instructions** – at the end of Unit 4, evaluating your product, and developing user instructions or care labels.



The SAT – an approximate breakdown of parts

UNIT 3, AREA OF STUDY 3: DESIGNING FOR OTHERS

An end-user?

This study encourages you to design an exciting and innovative product for an end-user and to consider a broader audience for your work in the future.

The purpose of designing for others is for you to use feedback from other people throughout the design process, and not just make all the design decisions yourself. It is to prepare you for your later working life, where you will often be accountable to others.

Before starting the SAT, you need to decide on an end-user that you will be designing, making and evaluating a one-off product for. This could be:

- a specific person whom you know, such as a family member, friend or teacher, and who will provide you with feedback in the development of the product

9780170400336

- a typical end-user of a target group from whom you have the ability to get feedback. Examples are: young carpenters, elderly mobile-phone users, teenage students. In this case you can use neighbours, friends, classmates or family members for feedback. The product could be designed and made as a prototype with low-volume or mass production in mind
- an end-user from a broader group with a global or humanitarian problem, in which case you would gain feedback from classmates or from an online forum.

Ideally, you will have one or two individuals to give you feedback throughout the SAT. (If you are the end-user, you need to find people who are similar to yourself to give you feedback.)

Investigating and defining

Interview or market research

You are to conduct research about your end-user/s. You can do this by interview or market research. Interview questions can be created easily by referring to the product design factors. Write the nine factors in a list and create a relevant question for each factor (or several questions per factor). Delete the factors that are not relevant, but you should aim to cover a minimum of six factors.

Market research will require inventive searching (probably on the Internet) also based around the product design factors. Or use the same interview questions and ask several end-users. *Refer to Chapter 12 for market research sources.*

Purpose, function and context
What is the need for a Swordcraft costume?
What would be some functions of the costume?
How often will the costume be used?
What kinds of additional features would you like in your costume? (pockets, sheaths/holsters for swords/handguns, etc.)

User-centred design
On a scale of 1 to 10 how comfortable must the costume be to
a) run in
b) stand still in
c) stretch/bend/twist in
d) sit or lie in?

Innovation and creativity
What are some really new and different things you wish women's costumes had?

Visual, tactile and aesthetic
What parts of the costume do you think should be emphasised?
Does symmetry/asymmetry in the design matter to you?
What textures and colours would you like in your design?
How would you like these textures and colours combined?

Sustainability
Are you concerned with the sustainability of your garment? Explain, e.g. leather/other animal-based materials, synthetic materials, recycled/upcycled materials for your garment? Bear in mind that this may raise the materials cost.

Economics
What is your maximum budget for materials costs?
And what is your preference re: costs?
a) cheaper materials *or* quality materials
b) more time spent on decorative details *or* more time spent on things like hemming, fasteners, and other structural details
c) shorter production time (get the garment sooner) *or* longer production time (more time spent)

Materials – characteristics and properties
How durable do you want your fabrics to be?
How easily washable do you need the fabrics to be?
How heavy would you like your material to be?
Would you prefer your materials to be more rigid or more flexible?
Where is it acceptable to you to have very rigid fabrics? (Shoulders, arms, cloak, etc.?)

Interview questions, by student Bethany Hedt

9780170400336

End-user profile

Provide information about the end-user in a profile. You need to give a feeling for who they are; their lifestyle, tastes and needs.

Aim to make the profile communicate visually rather than being full of text. Add colour, texture and images to convey the end-user's taste.

End-user profiles, by students Meg Angelini (left) and Tino Mubayiwa (right)

The design brief

Write your design brief, outlining the design problem or situation and its requirements (constraints and considerations). Ensure that you include all the product design factors that are relevant to your design situation. Set out the design brief as you did for Outcome 1. Give it a big heading, 'Design brief', with sub-headings 'Outline of context' and 'Constraints and considerations'. *See page 12 in Chapter 2 for suggestions.*

Highlight the requirements in your brief and annotate them to show which product design factors you have covered. *See page 339 in Chapter 12 for an example.*

Include an indication of the quality expected in your finished product. Rather than writing 'high' or 'good', be descriptive. For example:

- All pieces must have the grain in the right direction (wood or fabric).
- All parts (name them) are required to be symmetrical.
- All joins (name them) must be straight with no gaps or missed bits.
- Finishes (name them) must be applied (describe the manner) for the whole product.
- Must fit (name what or who it must fit) reasonably accurately.
- Include any functional aspects and describe how you expect them to work.

More examples are given on page 17 in Chapter 2 under 'Indicating quality'. Writing evaluation criteria is explained on page 19 in Chapter 2. **Re-read this section before commencing.**

The evaluation criteria

As a reminder: evaluation criteria must come directly from the design brief. They are a repeat of the important requirements but written as questions. The same questions can be worded differently to apply to your design option drawings and your finished product, as not all the evaluation criteria will be able to be 'answered' from your drawings.

Evaluation criteria in Unit 3:

- need to address both the design option drawings and the finished product
- can be reworded to suit the design options (from those directed at the finished product). *See page 19 in Chapter 2 for suggestions on how to do this*
- are written in four parts for the finished product – criterion question, justification, ways it can be achieved, and how the product will be tested/checked when it is finished. *See page 20 in Chapter 2 for suggestions on how to do this*.

Refer to the current Assessment Criteria published in the *VCAA Bulletin* in February each year to see how your end-user profile, design brief and evaluation criteria will be assessed.

Graphic organisers

This is not mandated, but you can use a graphic organiser to expand on the highlighted phrases in your design brief, showing possible areas for research and design activities.

Alternatively:

- create a new page with a table outlining a research plan and design activities
- annotate research and design activities related to the highlighted phrases on a copy of the brief.

For whatever purpose you use a graphic organiser, be sure to add a heading that communicates the purpose clearly.

To revise how to use graphic organisers to indicate design and research activities, go to pages 257 and 341.

Research

Research should include relevant information and ideas for inspiration. Aim to include research from both primary and secondary sources.

Research for information

Before commencing your research, re-read the information on pages 21–8, taking particular notice of the sections highlighted in Units 3 and 4 colours. Your research for information may include:

- ergonomics
- relevant measurements and details of the setting
- availability of materials and colours (and costs)
- knowledge of materials (source, processing, characteristics and properties, sustainability, information from testing, etc.), fittings and fastenings
- processes (shaping, decorating, constructing and finishing methods, etc.)
- any other relevant product design factors.

Make sure you include the source of your information.

Research for inspiration

Your research for inspiration may include:

- images that inspire you
- products with similar functions
- products with interesting attributes
- objects from nature or the 'made' world
- mathematical patterns, etc.
- research of design styles (Chapter 11 can be a starting point).

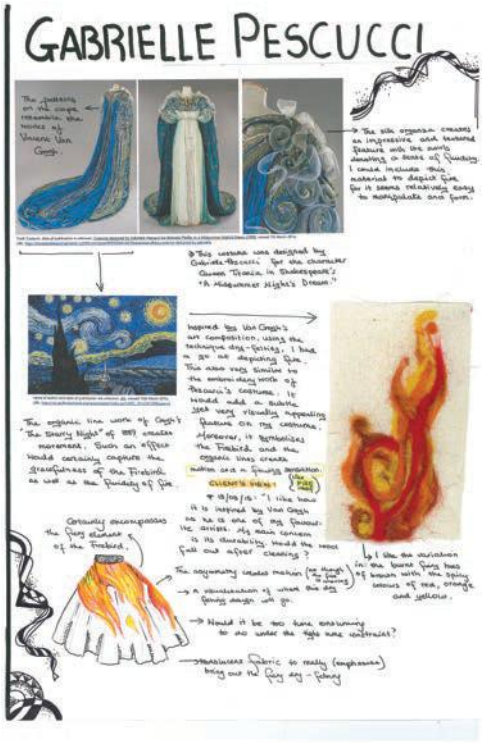
All of your research must be relevant to your design situation.

9780170400336

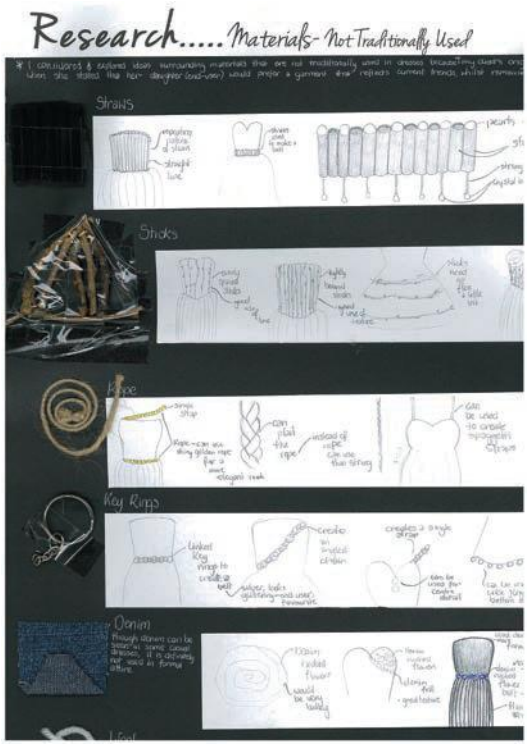
Intellectual property

Be sure to acknowledge the intellectual property or IP (moral rights) of the creator of a product in a photo, i.e. the name of the person whose work it is – by making it clear and

Client measurements by student Rebecca Carpinelli (left) and clear acknowledgement of IP by student Leya Mackus



Student Lian Wilson clearly attributes the creator of the work that inspired her



Student Katelyn Boehringer demonstrates ideas inspired by her own research

obvious to the viewer. For written information, give the source. This should be done for any work that is not yours, that you did not create yourself. *To revise IP, go to pages 108 and 247.*

Remember that Pinterest, Google Images and other social media sites are not the name of the creator!

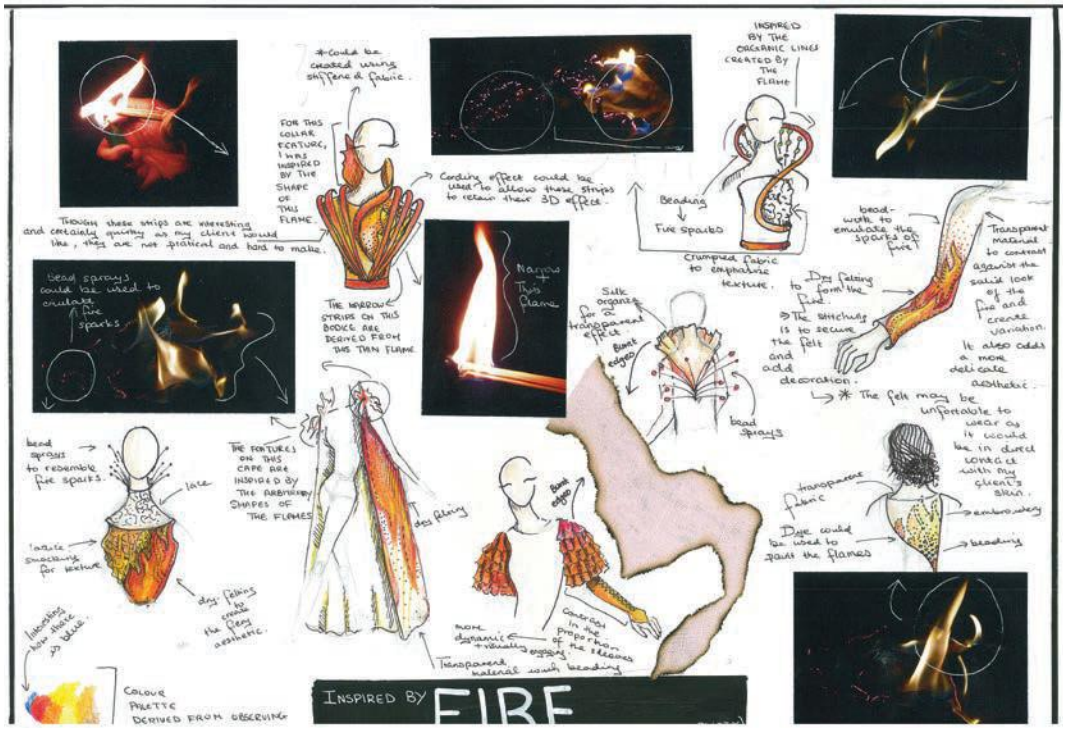
It is important to leave some room in your research pages for your own work, visualisations, that are part of the next stage in the process. By creating your drawings close to the research, links and influences can be clearly seen. Annotations and arrows also help. Research and idea development (visualisations) are often assessed together, by their connection and whether it is reasonably obvious. Refer to the current Assessment Criteria published in the *VCAA Bulletin* in February each year to see how your research and visualisations will be assessed.

Design and development

Before commencing this stage of the design process, re-read the sections on design and development on page 28 and sections related to your material area in Chapter 3. Think creatively (divergent) and critically (convergent). Use ideas and techniques such as the synectic approach and SCAMPER triggers to make sure you stretch the possibilities in your design. *Read more about all these methods in Chapter 3, on page 53.*

Once you have your 'creative and interesting' results, it's time to put on your critical thinking cap. Quality thinking comes from applying both a creative and a critical mind. Creativity is about going a bit wild and being experimental (taking risks), and critical thinking ensures you use your best analytical skills. It is the intellectual and rational component and an important discipline for good design.

Check information, be realistic and think ahead. Turn vague ideas into explicit, exact, definite and specific ones. Be pragmatic, and make decisions about what will work with the materials, skills and equipment available. Some critical thinking techniques are to research, to double-check information, to do some trials or tests to confirm possibilities, to balance pros and cons and make judgements, and to refer to your evaluation criteria.



A page of flame-inspired visualisation drawings, by student Lian Wilson

9780170400336

Asking the right questions is a good start – primarily, 'Why is this important to the brief, will this work, and how?' Annotations can help you record your thoughts related to critical thinking. *Use the techniques in Chapter 3 to help you.*

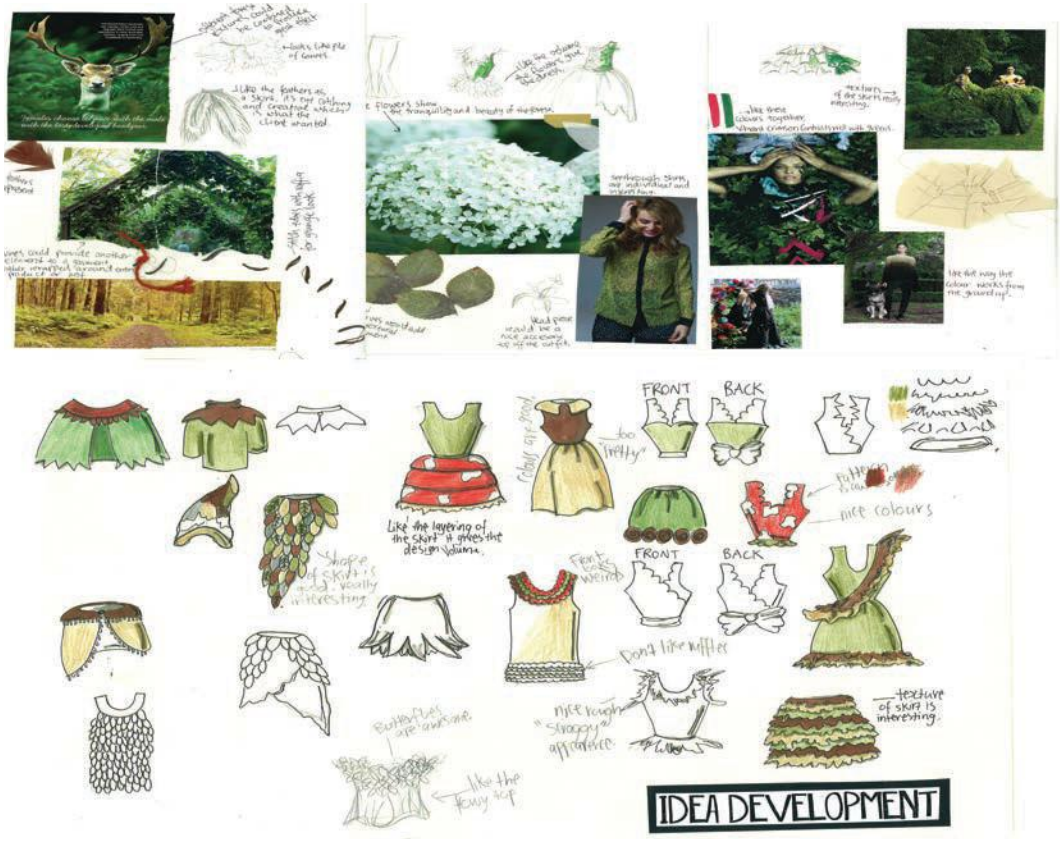
Graphic organisers for organising ideas

To revise prompts for creative and innovative design responses, go to pages 53–7. It is good practice to start your designing by sorting ideas into groups and an effective method is to use a graphic organiser. This will differ in content from the one you may have used to organise your research and design activities. Again, remember to give your graphic organiser a heading to show its purpose, what it is helping you with and what role it is playing for you in the design process.

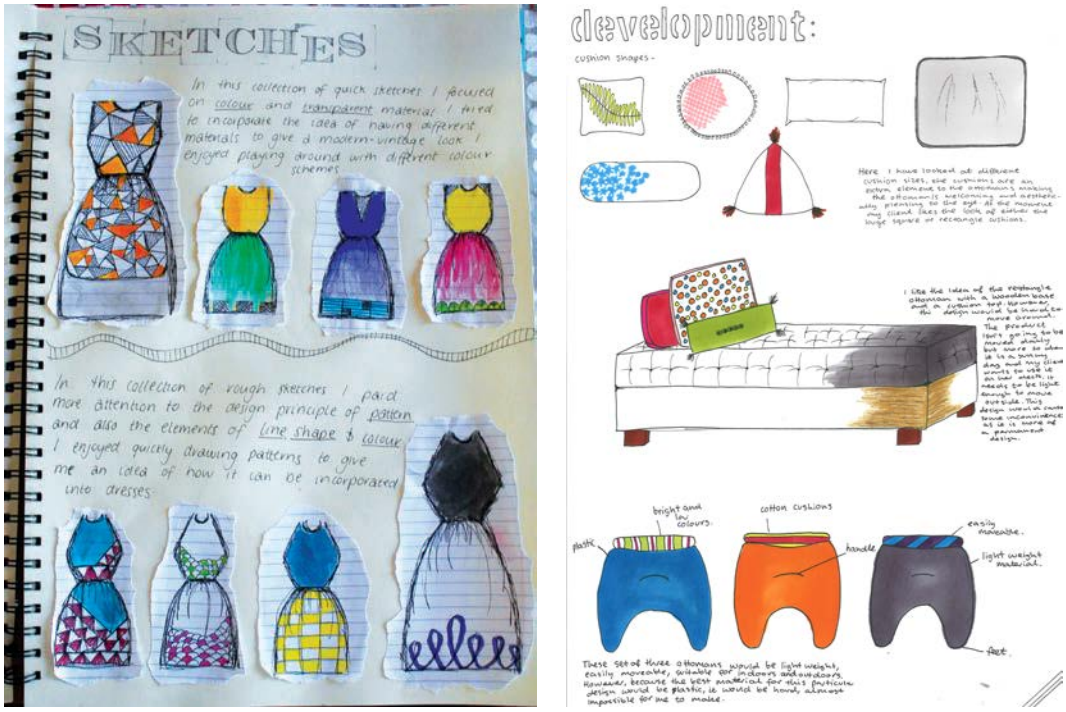
Visualisations

You are expected to create several A4 pages of annotated 'visualisations', which can be 'idea sketches', 'thumbnails' or 'concept sketches'. These are quick drawings with minimal detail that experiment with ideas. These early idea sketches can be of the whole product, or focus on different visual or functional aspects. Be sure to use bold outlines and colour. You can also do some mock-ups or 3D modelling as visualisations. Be sure to take photos to add to your folio.

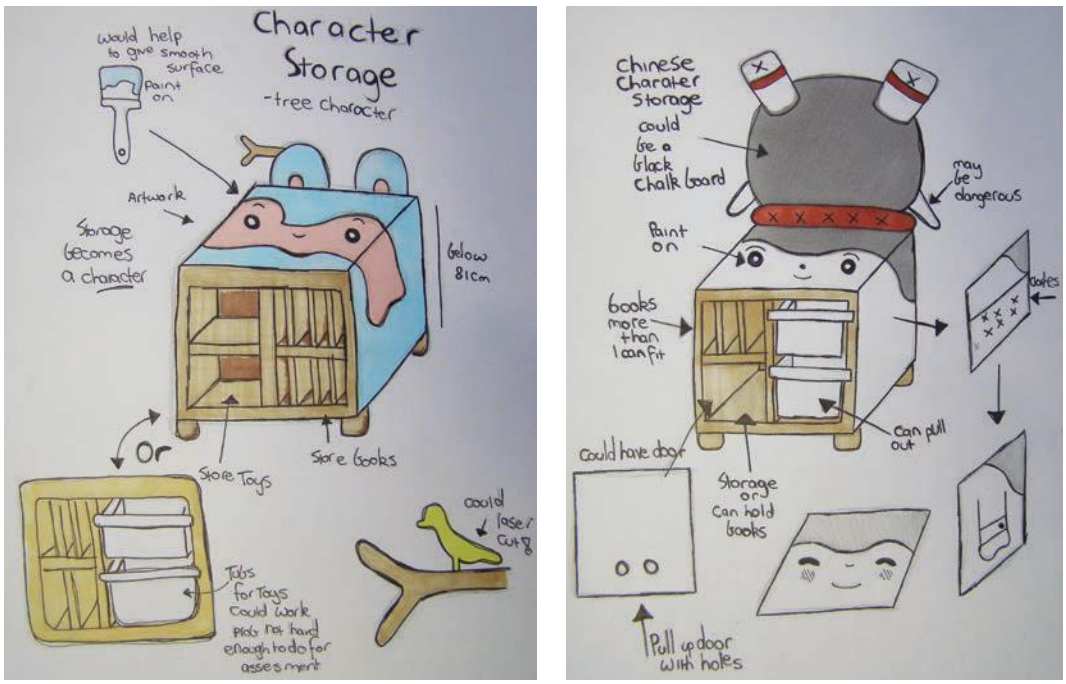
As stated earlier, visualisations are often assessed according to how they show links with your research and how they progress – like a design story. Place your first ideas in amongst your research so that the links are obvious. Aim to place at least half of your visualisations like this.



Coloured visualisations, drawn near their inspiration and reflecting woodland colours, by student Ashlea Payne



Pages of visualisations exploring the design elements and principles, by students Hope Shadbolt (left) and Sophie Allen (right)



Annotated visualisations for a storage unit, by student Kate Watts

Then add more on a separate page/s that are distinctly your own work. Use different drawing and communication methods (coloured paper, highlight boxes, photos of models, etc.) and ICT where appropriate.

Apply the critical thinking suggestions in the previous paragraph to differentiate the ideas you will bring forward into the design options. Use annotations to explain your thinking.

9780170400336

Annotations

Go to page 30 in Chapter 2 for details on annotations. Annotations are comments that explain a drawing or image further, including what can't be seen, and explain how the design idea solves aspects of the brief.

Write them on your:

- inspirational research **images** – to explain why they are in your collection
- **visualisations** – to note where the inspiration came from and to give the viewer an enhanced understanding of your idea progression and decision making
- **design options** – to explain how each one caters for the design brief requirements. Using arrows with annotations makes it easier for the viewer to see what is being referred to.

Refer to the current Assessment Criteria published in the *VCAA Bulletin* in February each year to see how your visualisations and the influence from your research will be assessed.

Design options (presentation drawings)

Design options represent your best ideas so far and provide viable choices to satisfy the brief. They are drawn in the presentation style (*see details on page 30 in Chapter 2*). From your visualisations, select the best ideas using feedback from an end-user. Combine the best ideas and create three to six design options. Remember that it is far better to present three detailed, clear, different, colourful and impressive design options than to complete more than six that show minimal differences, little colour and are of poor quality.

Present each design option on its own page (the minimum size being A4), number them clearly and annotate them. Use bold outlines, colour and texture to assist in the clarity of the drawing. Use the parameters of the visual, tactile and aesthetic factor.

There are a few things that you can include alongside your annotated design options that may support your ideas, e.g.:

- samples of materials (actual or photos) and information about costs per metre
- a small 'criteria grid', to score each design (see the student examples on the following page) and that has room for end-user feedback.

Refer to the method that Italian design factory Alessi uses to score products on page 372; where each criterion is scored out of five and a descriptive value is given for each numerical level.

Using ICT

You may prepare your design options digitally, but remember to present each option as a 3D image or rendered to show form in a garment with annotations as required. Add texture, colour and tone. A 2D drawing (e.g. an orthogonal drawing or a 'flat') is not recommended as a way of presenting design options.

Select the preferred option

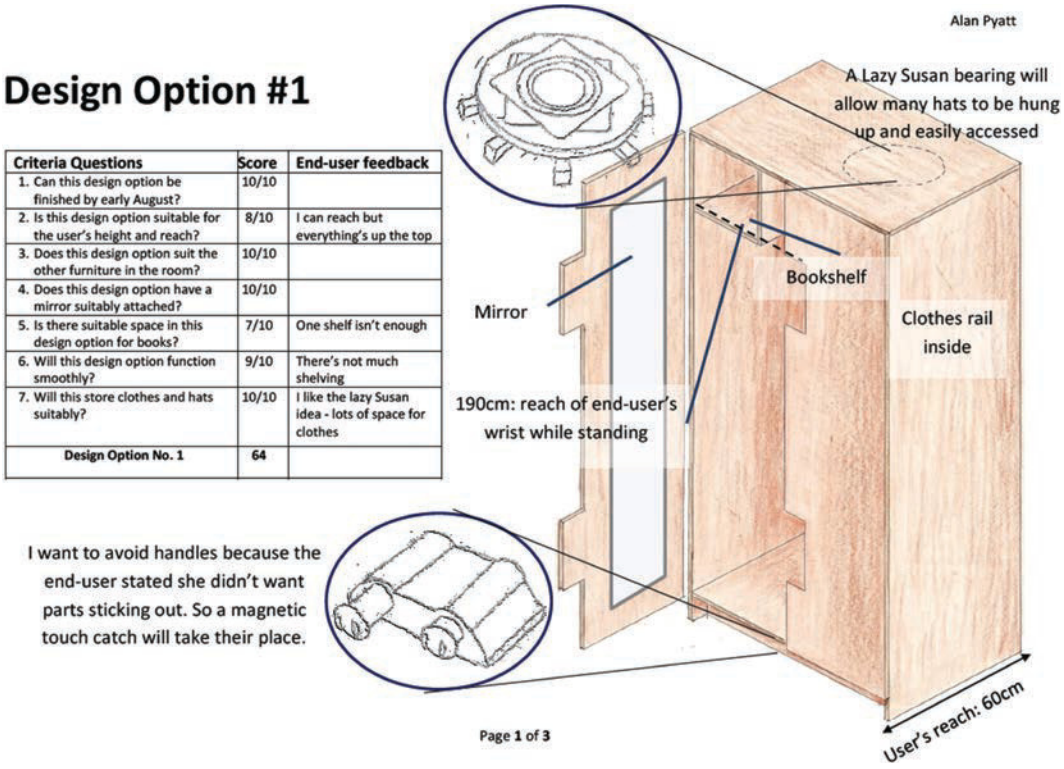
Apply your evaluation criteria to each option, using feedback from your end-user or a potential end-user. A little grid inserted on the same page as the drawing, scoring each criterion out of five is a useful communication tool.

An easy way to collate and compare the scores is to use a decision matrix or grid, where the highest score is easily identified (*see pages 32–3 in Chapter 2*).

Remember, you may require a new drawing if the preferred option ends up being a combination of features from more than one design option. See example on p. 35.

Note that criteria grids and a decision matrix are not mandated in this study.

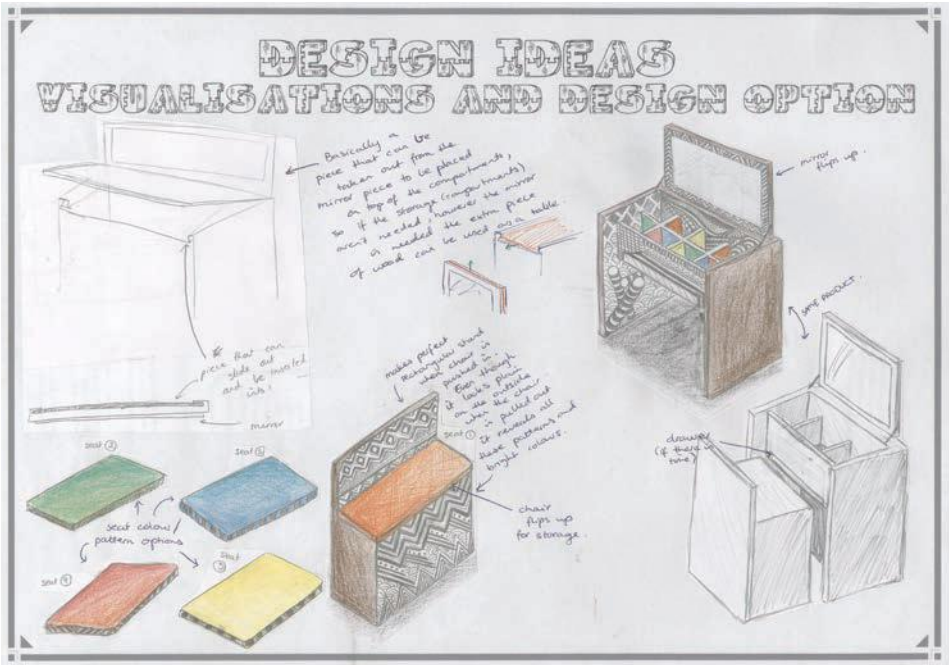
9780170400336



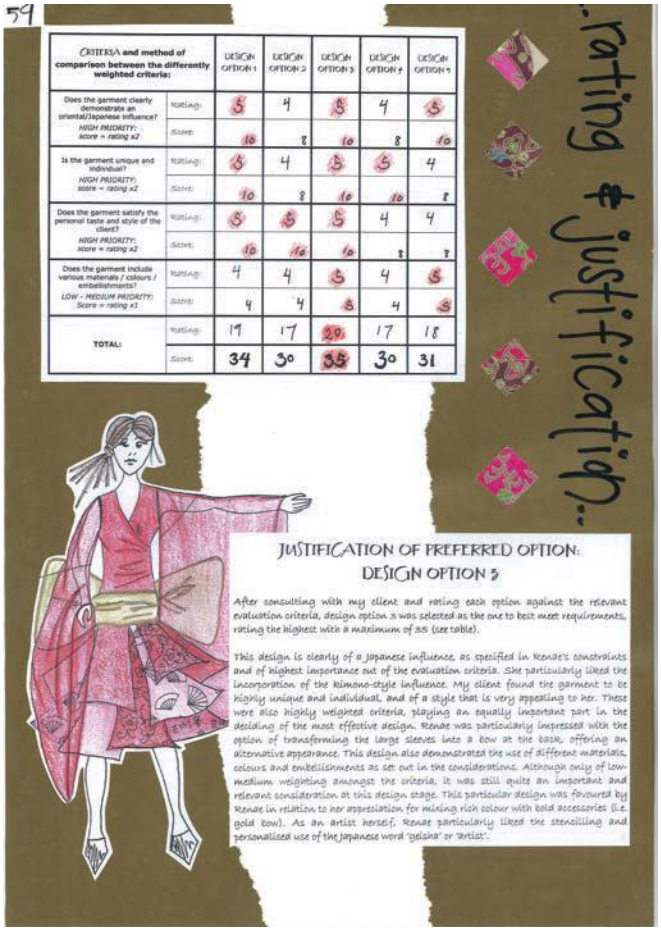
A design option, rendered, annotated, with user feedback and exploded details, by student Alan Pyatt

Design option 4, by student Leya Mackus: created from torn paper, fabric and pen, with pencil drawings annotated on a separate page; end-user feedback was presented on multicoloured paper

9780170400336



Visualisations and presentation drawings combined, by Year 10 student Mei Hong



Using a grid to show the preferred option (total score is highlighted), and written justification, by student Leya Mackus

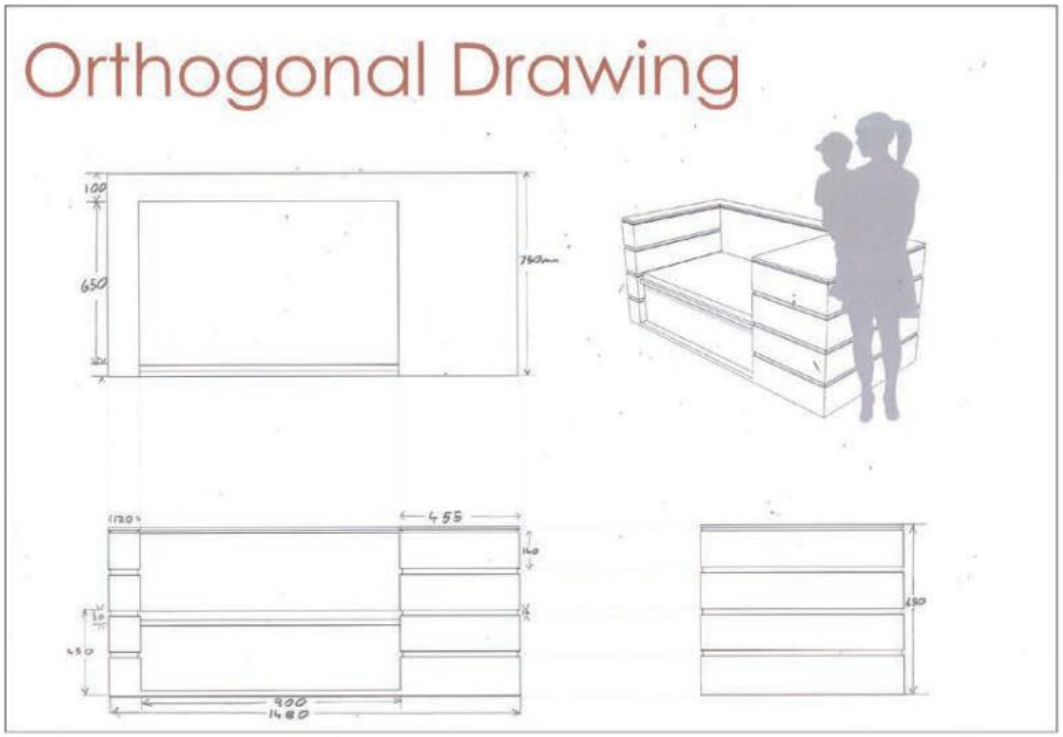
Justification

Write a justification of why the preferred option is the best choice, explaining how it addresses each of your evaluation criteria with reference to user feedback. Use visual methods where possible to clearly communicate which option is preferred. *For information and an example of a justification, read page 33 in Chapter 2.*

Refer to the current Assessment Criteria published in the *VCAA Bulletin* in February each year to see how your design options and justification of the preferred option will be assessed.

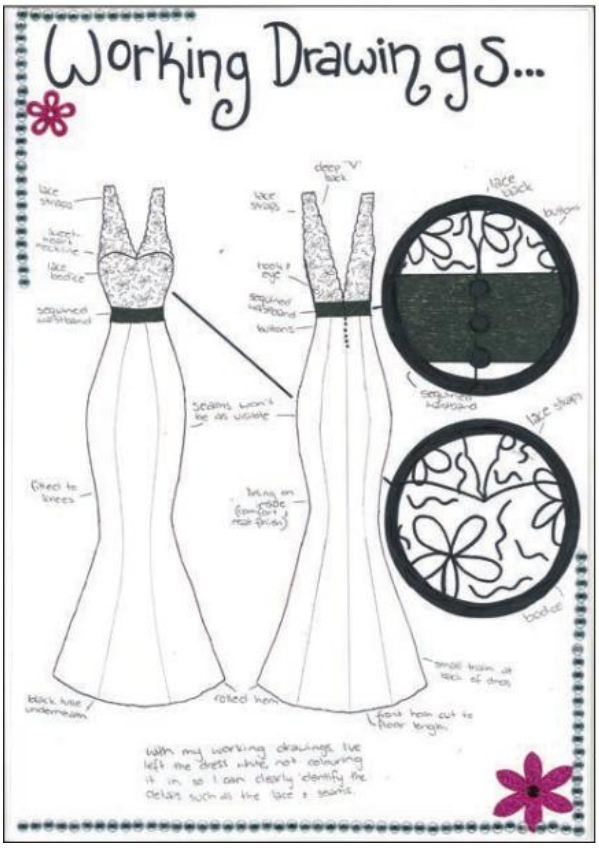
Working drawings

To revise working drawings, go to page 33 in Chapter 2 and the relevant materials sections in Chapter 3. Create appropriate working drawings of the preferred option using technical notations. If you are using a commercial pattern or plan, it is expected at this level that you will make adjustments and modifications to suit your preferred option. Working drawings need to show details of construction methods and accurate measurements (particularly for products made from wood, metal and/or plastics). These drawings indicate your product's specifications.

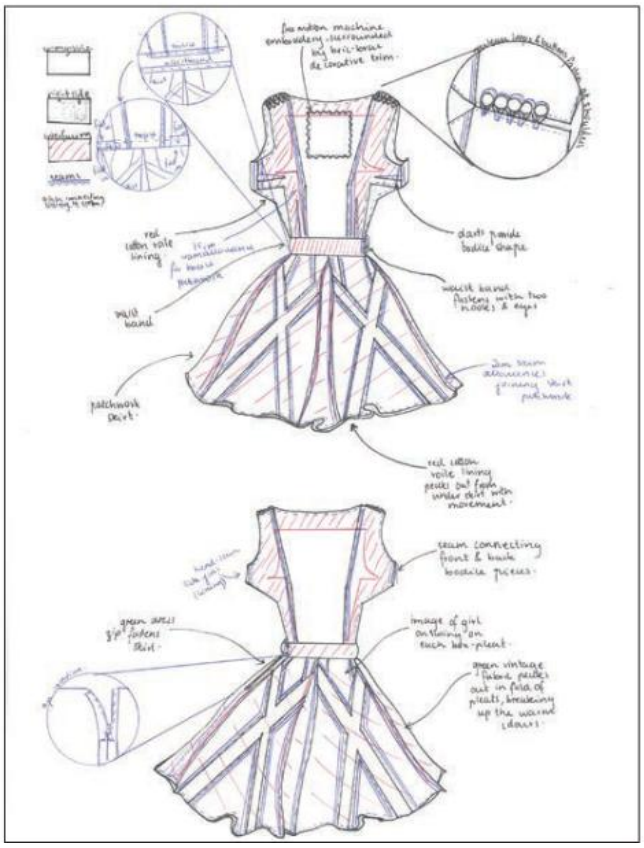


Working drawings by student Tino Mubayiwa

For garments and other textile products a 'flat' technical drawing is required.

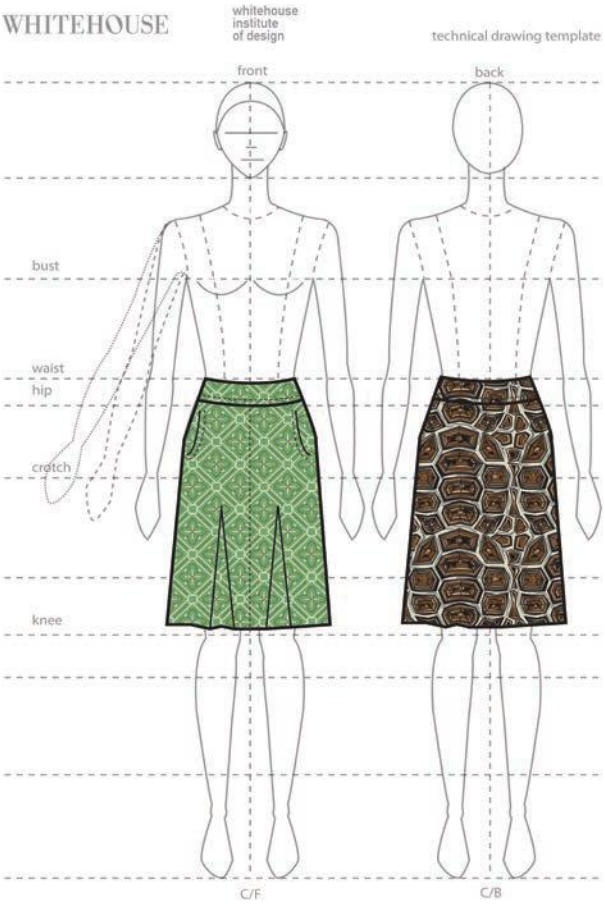


Working 'flat' drawing by student Tamika Sewell



Pattern drafting and adjustments by student Laura McKenzie

9780170400336



An example of a 'flat' drawing of a skirt with rendering done in Illustrator. Notice the alignment of back and front views.

Using ICT

You may prepare your working drawings digitally. CAD drawings are suitable for wood, metal and plastics; while Illustrator is suitable for garments. You can use the rendering tools as well but this is not required for the working drawings.

There are many tutorials on using Illustrator for 'flats' online.

Refer to the current Assessment Criteria published in the *VCAA Bulletin* in February each year to see how your working drawings will be assessed.

Planning and production

Planning

For guidance in creating your plans, look at the examples and follow the directions on pages 36–8. Remember that planning occurs before you start. You may not feel confident in predicting how you will make something or how long it will take but this is an important part of the process. It will help you be independent from your teacher and by keeping a journal of your actual process, it will also allow you to see how much you learnt along the way.

Create appropriate plans to make your product. In Units 3 and 4, your production (from measuring and marking out materials to finished product) should be planned to take approximately 20–30 hours. This depends on your situation, and the details will be determined by:

- your experience
- processes chosen
- testing required to make decisions
- any outsourcing to be organised
- any trialling and repetition that may be required to achieve a quality product.

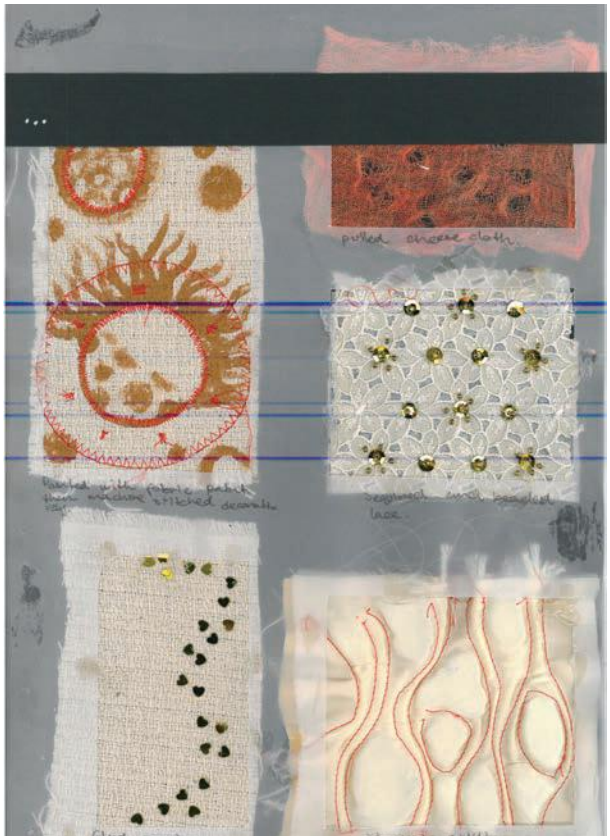
Components of the scheduled production plan

Refer to Chapter 2 for details on the planning components. You are required to have:

- expected sequence of production steps
- timeline
- materials and costing list that includes fittings and fastenings and purchased components
- quality measures (see also 'Quality in production' later in this chapter)
- risk assessment.

Knowledge of materials

At any stage in the design process it is really useful to experiment with and test materials or trial your skills, as this increases your applied knowledge, skills and experience. This might form part of your research or inform design decisions. Evidence of this can be placed in distinct pages in your folio (usually at the stages of the process when you carried out the testing and trialling). The purpose is to understand the characteristics and properties of materials you are using.



Evidence of material and skills trials, from the folio of student Grace Wallace

Manufacturing processes used in industry

In your folio, you are to identify relevant manufacturing processes needed to enable mass- or low-volume production of your preferred design. This will require research.

For example, you may have 3D printed a part of your product or the whole of it. This method would be too slow and too expensive to use in production of multiple products. It is a far better method for prototyping and the materials that print may not be suitable.

Some manufacturing processes that you could research further are listed in the following table.

Plastics	Wood	Metal	Textiles
• Vacuum forming • Blow moulding • Vacuum thermoforming • Injection moulding and extrusion	• Industrial creation of veneers and/or plywood timber to replace solid timber • Laser or CNC routing for cutting, drilling and marking • Using different materials, such as veneered MDF instead of solid timber • Machinery to handle large sizes, such as giant lathes and thicknessers • Use of knock-down fittings • Steam-press moulding for shaped timber or plywood pieces	• Robotic welding and fastening • High-pressure abrasive waterjet cutting • CNC milling • CNC plasma cutting • Specialist welding (TIG) for aluminium, stainless steel and copper, to join tubes • Specialised treatments for coating, plating and tempering metals	• Creating a specification sheet • Size grading of patterns • Pre-shrinking of fabrics • Create files for printing patterns onto fabric • Laser cutting (multiple layers), fabric burnout (devoré – can be done chemically or with a laser), digital printing, machine knitting, industrial sewing machines, machine button attachment, rivet pressing, heat transfer, fusing, finishing treatment machines for jeans (e.g. stone washing) • Attaching labels and swing tags

9780170400336

For other materials, type 'manufacturing processes for the material (e.g. composite materials, glass or ceramics)' or 'manufacturing process for the product (e.g. furniture, clothing)' into a search engine.

You can probably think of some more.

An excellent way to present this information would be to insert an image of the process as it occurs on your product and annotate it with suggestions for industry methods. Where possible, include an image of the manufacturing method. You could even mention sustainability aspects, either positive or negative, for the type of process.

Include a reason why it would be more suitable, such as:

- Veneered plywood could be used in this part as it will be lighter and cheaper than solid wood
- Knock-down fittings could be used for easy transportation from factories to retailers or consumers.

Techpacker is software for creating clothing specification sheets. Search also for the Online Clothing Study by Prasanta Sarkar, a textile engineer.

Slideshare has many prepared slides on manufacturing; type the word into the search facility.

Links to these websites have been provided at http://nelsonpdtvce.nelsonnet.com.au.

Embroidery machines for mass production

Refer to the current Assessment Criteria published in the *VCAA Bulletin* in February each year to see how your planning components; knowledge of materials, machinery, tools and equipment; and suitable manufacturing processes will be assessed.

Production

Towards the end of Unit 3, you should start production on your product. Use the information in the next section to get started, particularly on recording your progress on page 407.

UNIT 4, AREA OF STUDY 2: PRODUCT MANUFACTURE

Making your product

Product manufacture can begin in Unit 3, depending on your teacher's assessment of how prepared you are and how much planning you have done.

Follow your working drawings, plans, quality measures and risk assessment to make your product safely, efficiently and accurately.

Processes

You are required to use a range of processes, with different degrees of difficulty. Difficult processes require a great deal of planning, setting up, attention to detail and accuracy. Careful observation and decision making are important. The degree of difficulty can also be affected by the facilities and equipment available.

For example, planing undressed timber by hand for a flat surface requires effort, time, accuracy and good planing skills; however, putting the same piece of wood through a thicknesser requires much less effort yet produces a far more accurate result. The degree of difficulty of a process will need to be determined after discussions between the teacher and student, and consideration of safety requirements.

A 'range of processes' is considered to be a number of processes beyond the bare essentials needed to make a product. It is difficult to state the exact number of processes required, as this depends on the facilities, your skill level, and the requirements of your product design. Keep in mind that your production needs to be of a senior-level standard and should demonstrate this in terms of time and effort.

Quality can be achieved and improved on by practice runs or trials using scrap material.

Each of the processes listed in the table following is considered to be one process only, e.g. knitting is one process and would not be considered as covering a 'range of processes', even though it may include a variety of stitches and skills.

Some suitable workshop processes for VCE

Wood	Marking out Sawing Turning Screwing Dovetail joining Biscuit joining Filing	Waxing Veneering Scraping Ripping Carving Planing Sanding	Bending Laminating Oiling Drilling Crosscutting Shaping Staining	Routing Joining/assembling Scribing/squaring Finger joining Mortise and tenon joints Hinging Painting and varnishing Dowelling joints
Metal	Cutting Drawing down Punching Rolling Screwing Enamelling Etching Shaping	Bending Casting Annealing Sawing Filing Drilling Beating Turning	Riveting Lacquering Milling Brazing Colouring Forging Twisting Spinning	Surface finishing Metal folding Hard soldering Electroplating Painting Welding Polishing

9780170400336

Plastics	Bending Casting Twisting Turning Welding	Folding Sawing Filing Drilling Sanding	Hinging Shaping Riveting Planing Screwing	Vacuum forming Bonding/gluing Injection moulding Laminating
Textiles	Pattern layout Rouleau Darting Pin-tucking Dyeing Beading Top-stitching	Fitting Cutting Gathering Piping Overlocking Hemming Embroidery	Buttonholing Tacking Boning Pleating Draping French seams Knitting	Lace insertion Concealed fastening Collars/cuffs Elastic insertion Printing/painting Zip insertion Finishing treatments

Go to page 39 to revise risk assessment and use of tools and equipment.

Knowledge of tools, equipment and machinery

Throughout your production, you need to demonstrate that you have a sound knowledge of tools, equipment and machinery, that you can select the most appropriate piece of equipment for the task, and can use it skillfully, effectively and safely. Your teacher will observe you, but you can also choose to have evidence of this in your folio journal or log. Take (or find) photos of the main equipment pieces you will be using, annotate them to demonstrate their operating procedures and include information on:

- how to set them up
- how to change parts
- how to use them safely and accurately.

Dangerous machinery

There are a number of machines that can be used to perform some of the processes in the process table above, but which have a high level of risk and are very dangerous for students to use. These can only be used by students under strict guidelines (teacher properly accredited, thorough competency training and testing, and one-on-one supervision).

For a list of these machines, more detailed information of guidelines, useful risk assessment and machine safety procedures, refer to the DET website and look up 'Use of machinery in Technology teaching'.

Quality in production

Examples of things to check to ensure quality production

Products made from fabric, fibres and yarns	Products made from wood, metal and plastics
• No hanging threads • Symmetrical collars, pockets, sections, etc. • Buttons and buttonholes matching perfectly • Zippers attached perfectly with no gaps at the top or bottom, etc. • All seams caught properly and nothing missed by the sewing machine or overlocker • Reinforcements for all press studs, snaps, pockets and tops of zippers • Fabric patterns matching perfectly	• All timber selected must have a straight grain (unless chosen for a decorative feature) • Where possible, the materials selected should be free from damage • Marking out of materials needs to be double-checked • All dressing of timber must be accurate to 0.5 mm • All joins must be accurately made and have no gaps • Sanding and polishing must be done in grades to a high-sheen finish (all marking out, cutting and joining marks should be removed) • No glue, nails or screws should be visible • Finishes applied evenly

Add to your quality measures table as you learn more ways to improve your work. Your quality measures could be written in a table as such:

Process or part of product	Quality expected	Tips to achieve this
e.g. the collar, or inserting a zipper	Symmetrical, no missed edges, no hanging threads	Measure using (insert tool names) Tack into place first, etc.
e.g. housing joins	Square with no gaps	Use a set square to mark out, dry fit before adding glue, etc.

Recording your progress

Document your progress in a log or journal. This can be effectively done by taking photographs and adding captions/explanatory text. In your documentation, you need to describe:

- the work you did to complete each step of production (using both text and images)
- any modifications made to the process or the product; give reasons for change
- how well you followed safety guidelines and managed risks
- how you ensured and checked quality during production.

You could also discuss:

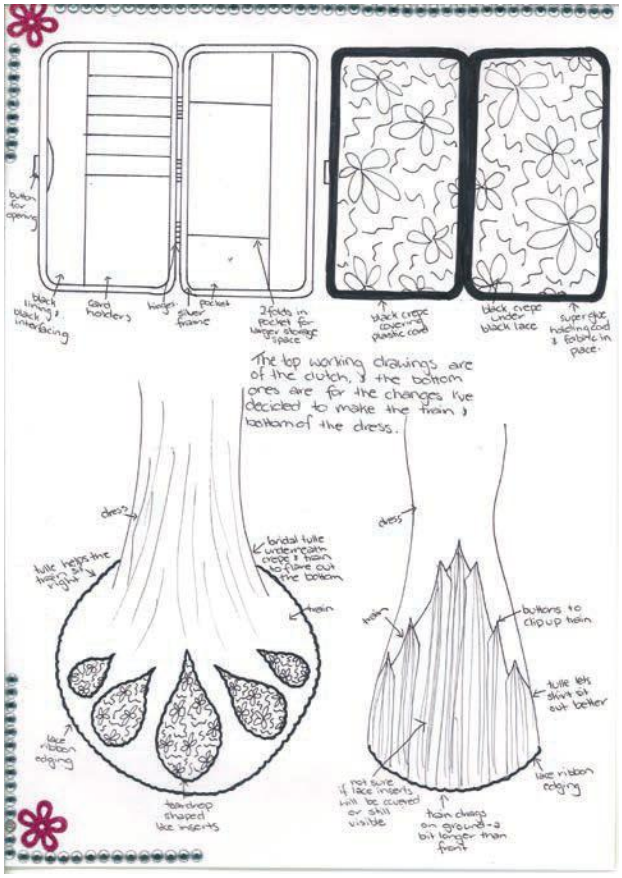
- what you learned about materials and processes
- how well and effectively you worked, in comparison with your plans and timeline
- any improvements (to the plan or product).

Your documentation should make clear:

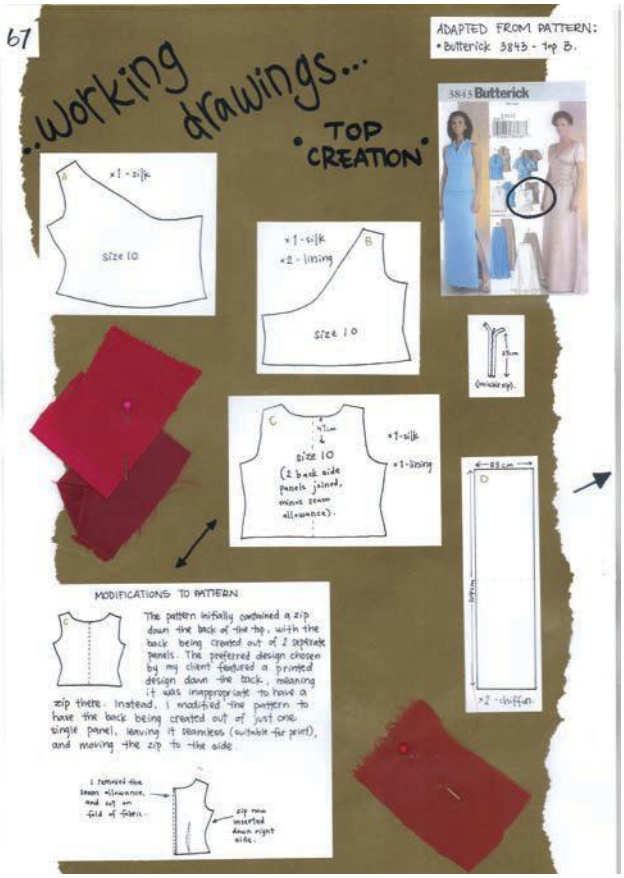
- what processes you completed and how
- any assistance you received
- any processes that were 'outsourced'.

Two pages from student Grace Wallace's folio, showing technique trials with samples and text

9780170400336



Using a diagram to show changes to the working drawing, by student Tamika Sewell



A log page using a diagram to show modifications to the pattern, by student Leya Mackus

A page from student Lian Wilson's log, with photos, dates and explanatory text

UNIT 4, AREA OF STUDY 3: PRODUCT EVALUATION

Evaluation

To revise evaluation, go to page 48. You have applied evaluation methods throughout the product design process, and now, at the end of the process, you need to write your final evaluation in a report.

Checking the product for the evaluation report

Start by applying the checking or judging methods (that you wrote for each of your evaluation criteria earlier in the process) to your finished product. In your report, explain how you carried out the checking or judging and add your response. Include feedback from your client or end-user.

Response to your evaluation questions requires more than 'yes' or 'no' answers. Provide an extended response that includes an explanation.

To prepare your report, a draft can be set out in a table, as below.

No.	Evaluation criterion	How it was checked	Feedback from end-user/s	My response and suggested improvements
1	Insert your question from the four-part evaluation criteria here	• Refer to your four-part evaluation criteria for the suggested checking methods • Explain clearly how you checked/tested the product and how you gathered feedback from the end-user/s	Write a comment here from the end-user/s	• State how you think the criterion was satisfied • Make some suggestions for improvement where applicable

A final report can be presented in an essay form but formatted clearly for easy communication. See below.

Evaluation report sample layout

My product and end-user/s: ... (give a brief description)

1 **Write the evaluation criterion question in bold on one line.**
Checked by ... (explain what you did to check it)
I gathered feedback from the end-user/s by ... (say how you communicated, what you showed, what you observed them doing, etc.)
Feedback was: ... (include some statements)
My evaluation is ... (your response to how your product fulfils the criterion)
It could be improved by ... (make suggestions where possible)
Optional: insert an image of the product part being referred to.

2 **Write the next criterion, and so on.**

9780170400336

To sum up, make a statement about the product and the extent to which it satisfies the design brief, perhaps covering aspects not discussed within the criteria. You could comment on:

- how well you ensured quality, i.e. suitability and accuracy of processes (e.g. cutting, shaping, joining, finishing)
- effective use of time.

Instructions and/or care requirements

You also need to create user instructions or care labels for the end-user, which highlight the features, assembly, care and/or repair of the product.

The instructions can be in the form of:

- an annotated image of your product (or prototype)
- a multimedia format (e.g. Microsoft PowerPoint, webpage or using other software)
- video tutorial (an image or footage of your product with a voice over).

Note that if you wanted to use your folio for an interview, it might be wise to check that digital formats are acceptable or whether all folio pages need to be printed.

Instructions for use

Instructions may be needed explaining the use of your product for the end-user. Only complete this activity if it is relevant to your product. For example, there may need to be instructions on:

- the assembly or disassembly of your product to enable it to be moved around or transported
- supporting the product in a particular way (for balance)
- specific safety procedures for your product's use
- ways to use and treat the product to prolong its use (i.e. gently or always to one side or only for particular uses)
- ways to use and treat the product to avoid breakage
- cleaning and protective treatment methods (e.g. waxing or polishing) that will prolong the product's life
- situations to avoid with the product, such as use by children under five, exposure to direct sunlight or contact with water.

As suggested above, this information can be presented in any of three ways, which could also highlight the best features.

Instructions for repair

As above – only complete this activity if it is relevant to your product. Parts or areas of the product may be vulnerable to wear and tear but easily replaced. Instructions could include:

- how to take apart the whole product to fix or replace areas (if applicable)
- how to remove and replace parts
- where to get new parts (if applicable) or how to substitute them
- what to do if holes or breaks occur
- how to mend (fix or patch) or disguise damage.

As suggested above, this information can be presented in any of three ways, which could also highlight the best features.

9780170400336

Care label

A care label is suitable for clothing and some other products. As with use or repair instructions, an interesting way to present this could be with an image of your finished product, e.g. facing each other in your folio. For commercial products, care labels can be made from many different materials. You can choose to use one of these materials or to present the information as a digital label (printed if required for your folio).

Care labelling is important as it helps consumers to care for products, alerts them to any care or maintenance costs involved and helps to make the product last longer. Before you can create your care label, you need to refer to your research about the material(s) and finishes you used and the care requirements for each.

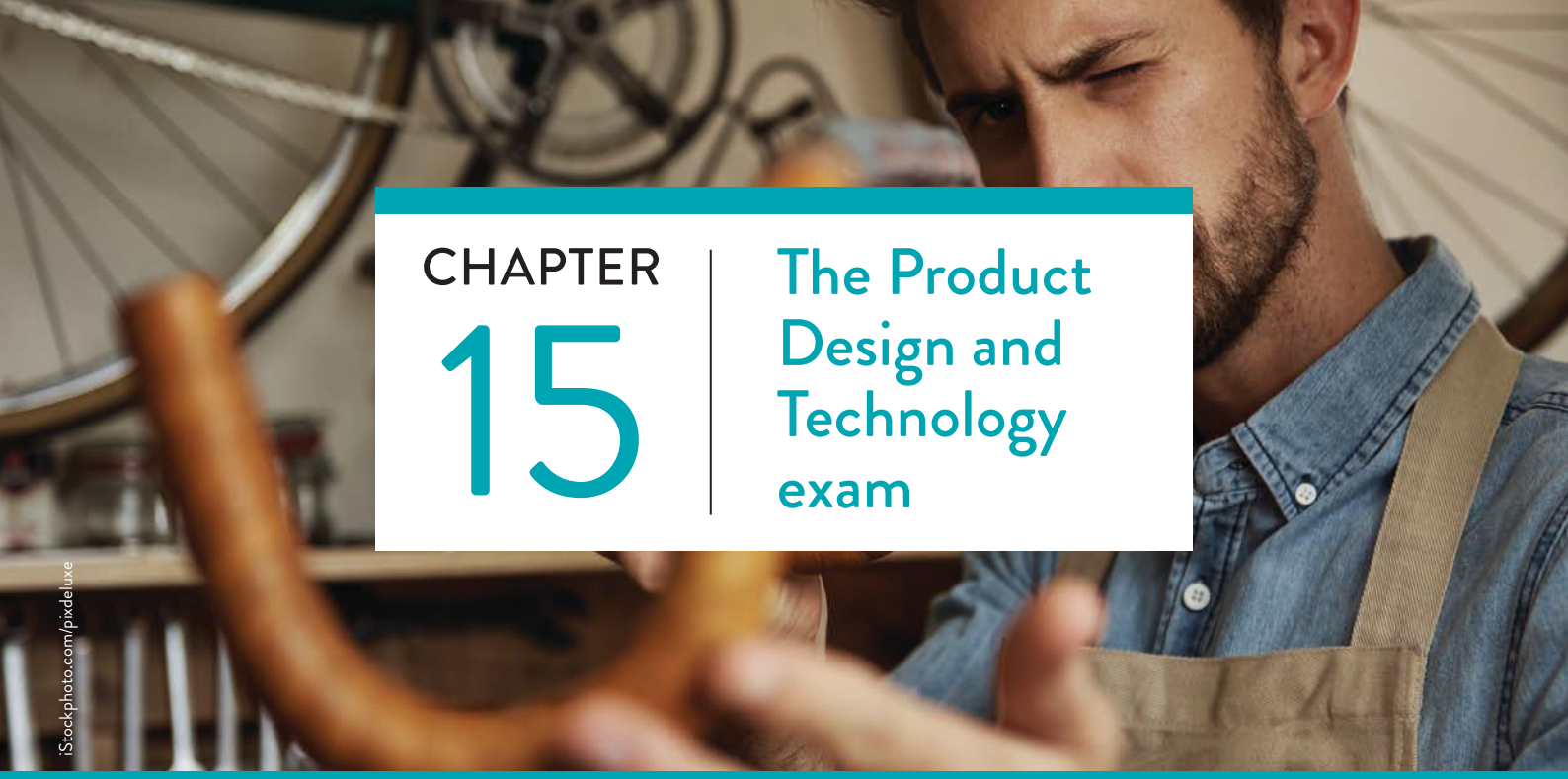
The Australian Standard for care labelling on any textile product (including furniture upholstery) is AS/NZS 1957: 1998. Information on caring for timber, metal or plastics can be found:

- from your supplier or the Internet
- in a manual, brochure or magazine related to the material(s) used
- on the container of any finish that has been applied
- from your teacher or an expert
- from your own knowledge or experience.

Keep your care label simple and concise – look at some of the product and clothing labels around your house for ideas on this!

The Australian Competition and Consumer Commission website has information on AS/NZS 1957: 1998 'Care labelling for clothing and textiles' – go to 'Bans, standards and recalls', then 'Mandatory standards'. A link is provided at http://nelsonpdtvce.nelsonnet.com.au.

Care labels: for a piece of furniture, by student Jon Scampton (top); for a stretch polyester satin skirt and a polyester top, by student La Nee Isherwood (left); and for a 100% silk garment with 100% nylon netting, by student Rachel Krause (above)



iStockphoto.com/pixdeluxe

CHAPTER 15 The Product Design and Technology exam

CHAPTER FOCUS

In this chapter, you will:

- Learn about the structure and content of the Product Design and Technology end-of-year exam p. 412
- Review the examinable content of Units 3 and 4 and the Cross Study Specifications p. 414
- Develop strategies to understand and tackle exam questions p. 420
- Practise the skills needed to perform well in the exam p. 423

This chapter links to online revision resources and a practice exam.

Your end-of-year examination is worth 30 per cent of your study score. It is also used to verify your SAT mark, so it is important to try to achieve the best mark possible in the exam.

Exam content

The exam questions will focus on the following areas of the curriculum:

- the **Cross Study Specifications** – these are critical to know, and include:
  - the product design process, with its four stages and 10 steps
  - the product design factors and their parameter descriptions
  - materials
- content from all outcomes in **Units 3 and 4**
  - **SACs** – Designers for end-user/s, Product development in industry, and Product analysis and comparison
  - knowledge from your **SAT** experience – Designing for others, Product manufacture and Product evaluation
- the **Glossary** of key terms.

This means that anything you have studied and learnt during Units 3 and 4, or that is contained in the product design process or product design factors, is assessable. A topic that was a focus in Units 1 or 2 might be assessed if it is specified in a product design factor parameter.

9780170400336

Exam structure

The structure of the exam may change slightly from year to year, but it usually has the following parts:

Section A

- This section consists of short-answer questions, and a longer format mini-essay question, that focus on defining and applying concepts. It may also include multiple-choice questions.
- A photo and brief description of an example product may be given – you will be asked to apply concepts contained in the product design factors, knowledge from the 'Product development in industry' outcome, etc. to the example product.
- There will also be some general questions related to concepts in the Study Design.

Section B

- This section is based on a design scenario and brief – you will answer questions related to the brief, draw and annotate a design option, annotate one or more diagrams of production processes and explain your design choices. You may be asked to consider the application of steps in the product design process or factors related to possible mass production of your product idea.

Equipment for your exam

You may take the following into your exam:

- pens
- lead and coloured pencils
- water-based pens and markers (no Copic markers)
- sharpeners and rulers
- erasers
- highlighters.

Note: things you *cannot* take into the exam include shape templates, body shape guides (croquis) and grid paper. This list may alter from year to year, so check with your teacher.

Useful question terminology

Key words in the exam questions give you an indication of the types of responses that are required. When you read through the question, highlight these key verbs as well as the subject content that is being asked for.

Key verbs	Description
List, name	Name one or more things, give a brief response (words or short phrases)
Identify	Pick out or choose something significant from a range of possibilities – again, a brief response, usually without discussion
State	A brief response but should be a phrase or a sentence
Define	Explain what a word or term means
Describe	Give details of a situation or your choices, 'paint' an image with your words
Explain	Give a reason for your answer or choice, clarify
Discuss	Look at both positives and negatives of a situation, usually an extended response
Justify	Give reasons for your answer or choice, listing the important factors that pointed you in that direction or informed your choice
Outline	Give a brief overview
Compare	Look at the similarities and differences between things
Evaluate	Consider the pros and cons of the situation, analyse/balance them and come to a conclusion/judgement

9780170400336

Exam questions often have two or more parts to them – you may be asked to identify and describe, or list and explain, etc. Make sure you carefully identify the right answer for the first part – if this is wrong, the second part will be, too.

Key concepts for assessment

The product design process

Stage	Step	Further detail	What you need to know and show
Investigating and defining	1 Identifying the end-user, need, problem or opportunity		• Ways of researching information about the end-user, the need
	2 Design brief	Outline of the context, constraints and considerations	• Purpose of the brief • Its use in other steps and stages • The use of the product design factors in writing the brief
	3 Evaluation criteria	Development of criteria to reflect the important requirements in the design brief	• Four-part evaluation criteria • Their use to choose the preferred option and evaluate the finished product
	4 Research	Research into factors related to the design brief: materials and process investigation (tests and trials to inform decisions)	• Areas to research (product design factors) • Connection to the brief • Primary and secondary research • Influence on design ideas
Design and development (conceptualisation)	5 Visualisations	Concept sketches and drawings, mock-ups and 3D modelling of whole or part of potential ideas to meet the requirements of the brief	• Connection to research • Annotated reflection and analysis • Creative and critical thinking
	6 Design options (presentation drawings), selection and justification of the preferred option	A series of potential solutions evaluated to determine which best suits the requirements of the design brief	• Appropriate drawing styles • Use of design elements and principles • Annotation • Using the criteria and feedback to choose the preferred option
	7 Working drawings	Drawings including technical drawings, showing product specifications (i.e. sizes and construction methods) needed for production planning	• Scale, accuracy of dimensions, clarity and detail in drawing • Choice of production processes
Planning and production	8 Scheduled production plan	Sequenced plan and timeline, listing tools, equipment and machines with risk assessment and materials list Quality measures	• Detailed and logical ordering of production steps • Different components of a production plan
	9 Production	Product/prototype and production record. Refinements and modifications may be made throughout production	• Knowledge of a range of complex production processes • Skill, precision and accuracy • Reflection in journal
Evaluation	10 Product evaluation	Evaluation of prototype/product quality using evaluation criteria and end-user feedback. Recommend improvements	• Effective use of criteria and feedback to judge product • Methods of testing/checking criteria • Judging of quality

9780170400336

Product design process
Planning and production

REVISION ACTIVITIES

1 Write down all the steps and stages you went through while completing your SAT (think about the components of your folio, your production work and your evaluation report) and describe how these activities helped you to develop a successful solution/product.
2 Identify the activities you carried out that used *creative* thinking and those that used *critical* thinking. Were there specific strategies you used to help you to be creative (e.g. SCAMPER) and critical (e.g. PMI)?

Product design factors and their parameters

These product design factors influence the decisions that designers and manufacturers make when developing products. There are nine product design factors:

- Purpose, function and context
- User-centred design
- Innovation and creativity
- Visual, tactile and aesthetic (design elements and principles)
- Sustainability
- Economics – time and cost
- Legal responsibilities
- Materials – characteristics and properties
- Technologies – tools, processes and manufacturing methods.

You need to know all of the product design factors, and you need to know the *parameters* of each factor (the description of the details related to the factor). This information can be found in the *VCE Product Design and Technology Study Design 2018–2022*.

In an exam, you might be asked to:

- define or explain a product design factor (using its parameters)
- identify a factor that may have influenced the design of a product, and explain how it has been applied
- identify how you have addressed a product design factor in your design drawing.

Product design factors

REVISION ACTIVITIES

1 To help you remember the product design factors, develop a concept map for each one, showing the different areas covered by its parameter and exploring how each area has an impact on design (hint: use phrases and sentences where possible in your concept map). Display these maps where you'll see them frequently.
2 Carry out an image search on the Internet for 'new products' or 'innovative products'. Choose a number of products and:
   - consider how each of the product design factors might have influenced the designers of each product
   - consider how the product successfully addresses specific product design factors
   - identify research that each product designer might have done related to specific factors.
3 Identify the areas in the product design factors that you might not have covered well in the outcomes of Unit 3 and 4, and review those areas in more detail (e.g. look them up in the index and re-read the related sections of the text). Such areas might include Materials characteristics and properties, Intellectual Property (IP), Australian Standards, OH&S, etc.

Ottobock Australia Pty. Ltd.

Deglon

iStockphoto.com/ymgerman

Left: Examples of innovative products that you could explore when doing Revision Activity 2 on the previous page: Ottobock prosthetic limb designed for running and high activity; middle: Deglon 2-Inch Finger Guard Digiclass, stainless steel; right: quiet and powerful Dyson Air Multiplier bladeless fan

Designing for end-user/s

You need to know about:

- how designers use the product design process
- tasks that designers carry out – liaising and communicating, defining, researching, drawing, modelling (both physical and virtual), developing and presenting options, trialling, producing, evaluating
- how designers identify the 'needs' of end-users – personal experience, being the end-user, observation, listening to consumers, seeing problems in existing products or situations, prompted by manufacturer, market research, awareness of all aspects that influence the use or the users of an intended product
- methods of market research that might be used
- thinking and organisational 'tools' designers use – design brief and evaluation criteria with reference to product design factors, graphic organisers (brainstorming, Venn diagrams, concept maps, Lotus diagrams, mood boards, flow charts, etc.), drawing or visualising skills, creative tools (SCAMPER, etc.), planning, knowledge of materials and processes, critical analysis (PMI, criteria, etc.) and evaluation
- research and design – identifying how information in the design brief will direct research and design activities, including research methods used, design inspiration, ways designers explore ideas and strategies to expand creativity, tests and trials of materials and processes, etc.

REVISION ACTIVITIES

1 List different forms of market research, and explain the type of information that each would provide, e.g. user trials of existing products or a prototype that would identify any issues with how a product/prototype is used, and areas that might be improved.

2 Review the product design process and identify all of the steps in the process where a designer might have contact with end-user/s – how does that contact help the designer to develop a successful product?

Product development in industry

There is a lot of examinable content in this outcome. You need to know about:

Topic areas	Details/further description	Areas you need to consider
• Research and development (R&D) (pp. 348–50)	– scientific and technical research, needs to be experimental in nature	– the types of research that can be done through R&D (into materials, engineering, etc.) – how this differs from market research – how R&D gives a competitive edge
• New and emerging technology (pp. 350–4)	– including laser technology, robotics, CAD and CAM, CNC, rapid 3D prototyping (3D printing)	– benefits and applications – influence on design
• Lean manufacturing (p. 362)	– flexible and responsive manufacturing	– how this reduces waste, and streamlines design and production, ability to respond more quickly to consumer demand
• Innovation (pp. 356–7)	– developing new, cutting-edge ideas – applying ideas to new areas	– why innovation is important to the economy – how innovative thinking can improve product design
• Market research (pp. 336–7, 357–8)	– forms of market research	– how market research helps in the product development process
• The product development process (pp. 354–6)	– how products are developed, distributed, sold and modified in a commercial setting (mass production)	– the differences between the *product design process* and the *product development process* – expanded to include commercialisation (marketing and selling)
• Sustainability (social, environmental and economic) (pp. 358–60)	– sustainability frameworks, including life cycle assessment/analysis (LCA), cradle to cradle, design for disassembly, extended producer responsibility (EPR) or product stewardship – their influence on design, manufacturing, distribution and marketing	Sustainability impacts of: – the stages of a product's development (i.e. sourcing materials, production, transportation, use, disposal) – design strategies that can minimise impacts The three areas of sustainability: – *social* (health and wellbeing of workers and users, changes to lifestyle) – *environmental* (minimise environment damage, reduce waste, pollution, use of energy/fuel, water, carbon release, landfill) – *economic* (profits shared, fair wages for workers, community development, spread of wealth from sales)
• Obsolescence (pp. 360–2)	– planned obsolescence – style, functional and technical obsolescence	– problems and benefits to both producers and consumers (society)
• Scales of manufacturing (pp. 362–4)	– one-off, low-volume, mass production and continuous manufacturing	– how the method of manufacturing affects the design of the product (and vice versa)

Examples of possible products

Photo by Alessandro Sorci

Solari solar cooker
Solari is a completely fuel-less and highly portable outdoor cooker that harnesses energy from the sun to slow-cook meals without polluting the environment.

Photographer: John Frattasi Model: Emily Rainer. Bowerbags, www.bowerbags.com

Bowerbags
Designer: James Bowerman
Bowerbags is a modular, multi-functional travel bag system. The Bowerbuckle system connects all the individual bags together, to allow the user to create any combination of bags or carrying solutions they desire.

Lumen Labs, Inc. https://lumoshelmet.co

Lumos helmet
The Lumos helmet uses integrated coloured LED lights to indicate to others on the road when a cyclist is braking or turning. The lights are controlled by a wireless remote on the handlebars.

Note: all these product ideas were chosen as design finalists in the James Dyson Foundation Design Awards.

Product development in industry

REVISION ACTIVITIES: PRODUCT DEVELOPMENT IN INDUSTRY

1 Use the images of innovative products you found for the revision activity on page 415 or use the ones selected on page 418.
Consider the following questions:
- What market research might have been done during product development?
- What areas of R&D would have been helpful?
- How might new technologies have been used during the design and development of these products? (Be specific.)
- What is innovative about this product? How is it different from existing products in the same area? How is it better for the user?
- What scale of manufacturing would be used to produce the product? Why would this method be appropriate?
- What sustainability issues might be important to consider when designing the product? Discuss a particular framework of sustainability in relation to the product. What are the LCA stages of this product that might have significant impacts?
- Which forms of obsolescence might this product be affected by? In what ways might this be planned? What problems or benefits might this cause to the manufacturer, or the end-user?
- Explain how each of these products functions in an innovative way.

2 Create a detailed concept map for each of these topic areas. Display this in your classroom or room at home and review it frequently.

3 Develop a graphic way of representing the product development process based on a specific product.

Product analysis and comparison

You might be examined on the following aspects of this outcome:

Area	Details	What you need to know
• Qualitative and quantitative research methods (pp. 384–6)	*Qualitative*: smaller numbers of responses, detailed *Quantitative*: lots of responses, mostly numerical data	– What is the difference between these terms? – Describe different forms of data obtained from research and identify whether they are qualitative and quantitative – How survey questions could be worded to obtain qualitative data and quantitative data – Who might carry out these forms of research? – Explain how the information gained might be used in product design and analysis
• Sustainability issues that might concern consumers (pp. 381–2)	Sustainability = environmental, economic and social	– Identify possible areas of concern – Describe how people might consider these areas when choosing products, what they value and what information would help to make judgements in these areas
• Attributes (pp. 378–84)	What is an attribute? (a feature or quality of an existing product)	– How are attributes prioritised, and valued differently by different groups of people (designers, manufacturers, users/owners)?
• Quality (p. 382)		– What determines quality (e.g. material selection, production methods, quality of components and how they are attached, product performance, aesthetics)?
• Making judgements (pp. 384–5)	Weighing up all information (use the product design factors)	– How to develop and use criteria and tests to analyse and compare products – Use of product design factors – Making comparative judgements

9780170400336

Product analysis and comparison

REVISION ACTIVITIES: PRODUCT ANALYSIS AND COMPARISON

1 Develop a detailed concept map for each area in the table above – put this up in your room at school or at home.
2 Draw a table (three columns) with the nine product design factors written in the first column. Decide on a product that you would like to purchase. Write it at the top of the table. In the second column, for each factor, develop a criterion that *you* need the product to fulfil. In the third column, think of *someone else* who might need this type of product (different age, interests, life-stage, etc.) and rewrite/change the criteria to consider their needs and wants. In this activity, the criteria do not need to be questions. For the first product design factor, which is 'purpose, function and context', be sure to include the purpose or reason (including the person) for wanting the product.

Preparing for Section A

- Review content from the cross study specifications (the product design process and product design factors).
- Review the content of your Units 3 and 4 outcomes (particularly your SACs).
- Apply these concepts to:
  - products you see around you and use regularly; consider how they could be improved
  - innovative/new products you find on the Internet; consider why they are innovative and what issue they are trying to solve.

Multiple-choice questions

These types of questions are not included in all exams, but you need to be prepared for them. Multiple-choice questions will give you a statement or question, and then provide you with *four* possible answers. You need to choose the most accurate or best answer. Some of the answers given will be almost correct, but only one will be completely or technically correct. *You need to read the question/statement and all alternative answers very carefully.*

Extended-response questions

These questions are usually worth six marks and require you to write a mini-essay of approximately two paragraphs or about half a page. Your answer should be written in complete sentences, not in dot-point form.

These extended questions ask you to consider a 'big' concept, either related to the product design process or product design factors. Make sure you read all parts of the question carefully before you start writing. Note the following:

- There may be multiple parts of the area that need to be covered.
- You may be asked to make specific links between different areas (make sure these are clear).
- You may be asked to provide an example (read the wording carefully – if the question says to 'use an example to explain your point', you must do so or risk losing significant marks; if the question uses the word 'may', then it isn't compulsory to include an example in your answer, but it will help).

9780170400336

Practise answering extended-response questions. Your responses need to be clear and structured – this is difficult to do in your head without practice. Answer questions from previous years' exams and trial exams given to you by your teacher.

You should aim to answer these questions in approximately 6–10 minutes.

Preparing for Section B: Developing a product design

Section B has a design brief insert – this includes:

- a detailed design scenario, providing the context for your product design – the 'who, why, what, when, where', etc. of the design situation. It may also provide some visual design directions
- a range of products and their specific requirements (you only need to develop a design for *one product*)
- a list of complex processes for different material areas.

Read this insert carefully during your reading time.

Section B will ask you to use some steps of the product design process in relation to the brief, develop a solution (a drawn and annotated design option) and think about planning, manufacture and evaluation. You may also be asked to consider aspects such as quality, suitable tests, the product design factors, etc. in relation to the product design you have developed.

Questions before drawing your design option

You will be asked to analyse and consider aspects of the design scenario. You may be asked to:

- identify one or more constraints and write evaluation criteria based on these
- expand on aspects of the scenario related to the needs of the people or requirements of the place
- identify research that needs to be done before designing (may include developing a concept map).

Developing a design option

There will be a blank A4 page in the exam booklet where you are to draw and annotate a design option for *one* of the product suggestions. Make sure you read the design scenario and product requirements carefully, taking note of specific aspects you need to include or design for, such as size, visual features or style suggestions, indoor/outdoor settings, etc.

Choosing your product

You will be given a range of product options that use different materials and product types – usually a clothing outfit, furniture, accessories that relate to jewellery/identification, and an integrated material option. *Choose materials and a form of product that you are familiar with*, as this will give you the opportunity to show the examiners the depth of what you know about, and have experienced, in terms of materials and product design.

Use appropriate drawing equipment when drawing your design:

- graphite pencil (grey lead) – for planning and sketching your initial idea
- colour pencils, markers – to highlight and indicate colour
- fineliners – to outline, and write annotations
- rulers – to make sure your straight lines are straight.

Do not use ballpoint pens or biros for your drawing.

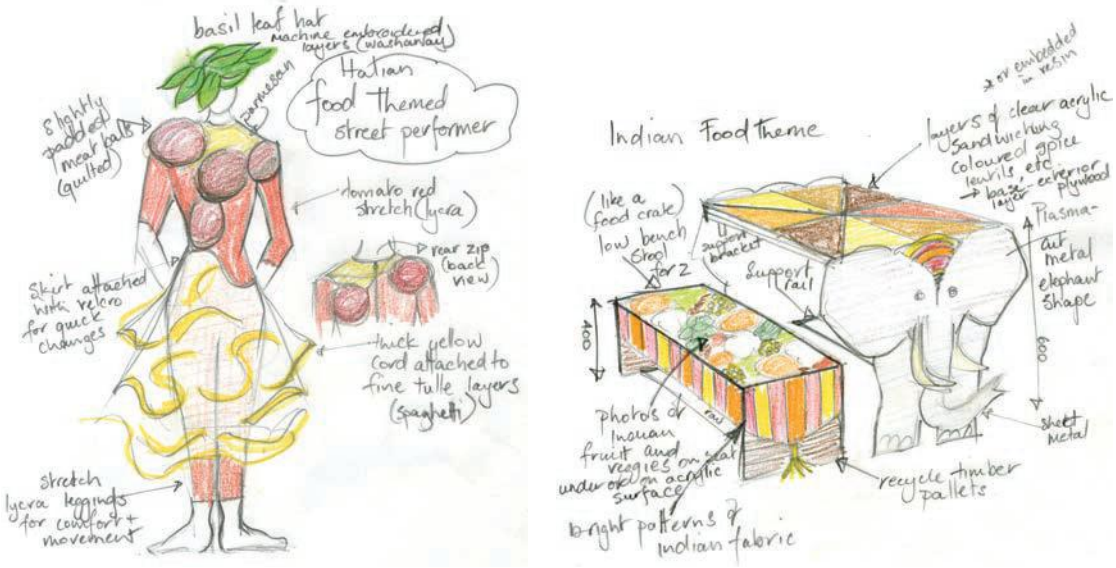
Prepare your drawing tools well before the exam – place them in a transparent case or zip-lock bag. Include coloured pencils and markers that will help you draw the materials you are likely to design with (e.g. a range of different browns and reds for timber colours, greys for metal, etc. – and other colours for highlights).

Use a presentation drawing style for your design drawing. For textiles/clothing products, that means a detailed drawing, which may be required to show front and back views. For wood, metal and plastics (WMP) products, you should draw a clear 3D view of the product, showing its front and side (an isometric or 2 point perspective sketch is appropriate).

Your design needs to be annotated. It is important that comments are legible and are in phrases, not single words. For WMP products, you can include major dimensions, particularly if they are included in the product requirements, but make sure they are appropriate.

Your design option will be assessed on:	What you need to include in your design options drawing
• how well it suits the design scenario (function/suitability)	– Make sure you address the needs of the people and situation (highlight some of these in your annotations). – Your product needs to be a workable solution (it needs to work well).
• the clarity and detail in your design	– Use an appropriate drawing style and clear, definite lines, shapes and colours. Make sure the product is easily understood from your drawing. Aim to cover at least half the page with the drawing.
• use of visual, tactile and aesthetic product design factor	– Make effective use of design elements and principles, i.e. line, shape, colour, proportion, balance, symmetry/asymmetry; and think about style (particularly if a visual direction or choice is given in the brief).
• the innovation and creativity you have shown	– Think of new, different ways to use the design elements and principles, and inventive ways to use materials, processes, etc. – Add unexpected elements – try not to be safe and conservative.
• annotations related to the design brief	– Your annotations need to be clear and readable. – Relate them to the brief and explain your design's features. – Include some descriptive comments, identifying materials and processes (and dimensions if needed). – Don't include too many annotations; don't crowd your design drawing with writing.

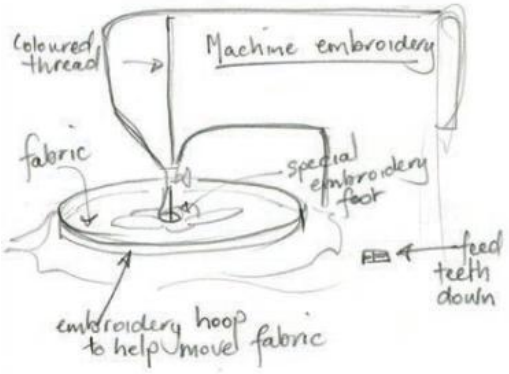
Note: you *will not* be provided with body shape templates or drawing grids in the exam paper, and you *cannot* take these into the exam to help you draw your designs.

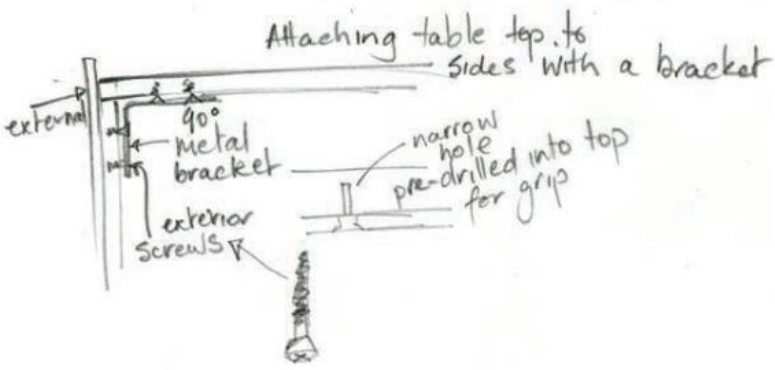


Possible solutions to the 2016 exam's 'World Street Food Festival' design brief

Drawing production processes

You may also be asked to draw and annotate between one and three diagrams of production processes – these can be shaping, joining or decorative processes that might be used in the production of your design. At least one of these processes will need to be from the list of complex processes provided in the design brief insert. Your processes should be named, and the drawings need to be clear and reasonably detailed, showing materials, tools and equipment. In your annotations, describe the parts of the illustration (indicating the tools, etc.), describe how it is carried out step by step, or explain why it would be suitable for the product.





REVISION ACTIVITY: ANALYSING A BRIEF

1 Read through the design brief inserts of past exams. For each:
- Identify three constraints and write evaluation criteria for each constraint.
- Identify methods of researching the user and situation.
- Draw a concept map for each brief identifying relevant areas for research (using some of the product design factors as a starting point).

PRACTISING DESIGN DRAWING

2 Practise drawing different existing products that relate to your material area.
- For textiles, choose different forms of clothing – formal, work and casual clothing, one- and multiple-piece outfits, clothing for males and females.
- For furniture and integrated materials, practise drawing a range of products – seating, storage, lighting, display, indoor/outdoor.
- For accessories/jewellery/identification (e.g. ID badges), draw objects that might attach to the body and clothing in different ways.

When you start practising, give yourself time to look at the object, drawing the shapes, structure and main features in detail. Gradually reduce the time you spend on each drawing, reducing the level of detail, but retaining the main lines and shapes and important features. Remember to use colour in your drawings to indicate materials, and to highlight features and patterns.

Drawing types

3 Use the scenarios of previous and trial exams to develop your design option drawing skill. Carefully read the scenario, highlighting the constraints/requirements you need to address in your design idea. Then develop an annotated design option for one or two of the products outlined. When you do this the first time, aim to complete your design drawing in about 30–40 minutes. As you complete further practice design options, reduce your time until you can complete a detailed, coloured, annotated drawing in approximately 15–20 minutes.
4 Practise drawing diagrams of processes that could be included in your design option. Complete around six, including three complex processes. *Refer to pages 224–37 for diagrams of textile processes and pages 165–72, 184–94 and 198–202 for resistant materials.*

Further questions: explaining and expanding on your design idea

After completing your design option drawing, you will be asked to explain and think about the next stages of the product design process, and possibly to apply other design concepts to your product idea.

You might be asked about:

- your material and finish choice, and how you might test materials
- your choice of production processes
- the way your product incorporates the visual and/or stylistic elements required
- the way you have designed your product to be durable
- the features of the product that are sustainably/environmentally designed (if required in the brief)
- planning for production – particularly what the components of a production plan are, and the purpose of each
- what the terms **efficiency** and **effectiveness** mean in terms of planning and production
- risks that might arise during production, and how you could manage and control risk
- working drawings – why we use them and how they are different to presentation drawings
- material tests, and why and when you might do them
- quality measures – standards expected and strategies to ensure high-quality work during production (consider preparing quality measures for each of these steps: selecting material, measuring and marking material, cutting or shaping, several joining methods, assembling and finishing)
- possible reasons for modification during production
- communicating with end-users for feedback during production or when finished
- evaluation – ways to judge whether the finished product suits the needs outlined in the brief, methods of testing the product and comparing it with other similar products, and the importance of user feedback in judging the product
- the care and maintenance needs of your product.

You might also be asked about:

- scales of manufacturing – be able to identify relevant processes that could be used in larger scale (i.e. mass) production of your product design, possible modifications to materials and processes if a change of scale is required
- research that could be used to assess the suitability of the product
- particular product design factors and how they relate to your product design
- relevant use of new and emerging technologies
- strategies of lean manufacturing that could be applied during design and production
- other concepts from Units 3 and 4 applied to the design and manufacture of your design.

9780170400336

GENERAL REVISION ACTIVITY: KNOWING YOUR TERMINOLOGY

It is important to know the terms that might be used in the exam – these terms may be crucial to understanding a question, or you might be asked to define them.

Write a simple definition for each of these terms in your own words (try not to just repeat the term words in a different order). Display the list in your classroom or room at home, and add to the list any other words you come across during your revision.

accessibility
aesthetics
anthropometric data
attributes
Australian and International Standards
CAD, CAM, CNC, rapid prototyping, laser and robotics
care label
commercial products
constraints and considerations
context
Cradle to Cradle (C2C)
critical and creative thinking
design brief
design elements and principles
design opportunities
design registration
designing for disassembly (DfD)
durability
embodied energy/water
ergonomics
evaluation criteria
extended producer responsibility (EPR)
intellectual property (IP)
lean manufacturing
life cycle assessment/analysis (LCA)
maintenance
market research
material categories (particularly wood, metal, plastics and textiles)
materials and costing list
materials characteristics and properties
materials testing
modification
new and emerging technologies
obsolescence
- planned
- technical
- functional
- style

parameter
patents
presentation drawing
prioritising values
process trials
product design factors
product design process
product development process (industry)
product specification
product stewardship
prototype
qualitative and quantitative research
quality
record of progress
research and development (R&D)
risk assessment
scales of manufacturing
scheduled production plan
sustainability
- environmental
- social
- economic

symmetry
tactile
time management
timeline
user feedback
user trials
user-centred design
visualisation
working drawing

Terminology

9780170400336

INDEX

1900s (fashion styles) 292–3
1910s (fashion styles) 293–4
  designers 294
1920s (fashion styles) 294
  designers 294
1930s (fashion styles) 294–5
  designers 295
1939–45 (fashion styles – World War II) 296
  designers 296
1947–57 (fashion styles) 297
  designers 297
  teenager wear 298
1957–67 (fashion styles – 'Swinging Sixties') 298–9
  designers 299
1970s (fashion styles) 299–300
  designers 300
  Glam rock 300
  high-end fashion 300
1980s (fashion styles) 301
  high-end designers 301
  influences 301
  New Romantics 302
  power dressing 301
  punk 302
1990s (fashion styles) 303
  designers 304
  grunge 303
  high-end fashion 303–4

A

Aboriginal and Torres Strait Islanders *see* Indigenous Australians
abrasion testing 148
abstract patterns 88
accessibility 100
accurate measurement (testing) 152
acetate 216
acknowledging your sources 27
acrylic 197, 198, 199, 201, 202
addition polymerisation 195
aesthetics 2, 15, 94, 381
  design 74–81, 381
  materials 115
AFRDI Green Tick 130, 386
age of a user 98
Alessi 370–2, 373–4
alloys 183
analysing a product to redevelop 250
  how does it appeal to the senses? 251
  how sustainable is it? 251–2
  what is the product, who is it for and what does it do? 250–1
annealing 188
annotated design brief 341
  example 18
annotations 398
  on design options 30–1
  of research 28
anodising 194
anthropometry 101–2
anvil 213
appliqué 237
architect or designer? 324
architectural styles, researching 270
Area of Study 1 (Unit 3) 333
  case studies 342–7
  demonstrating your understanding of 339
  designing for end-user's 335–42
  graphic organiser use 341–2
  preparation for the SAT 342
Area of Study 2 (Unit 3) 334
  case studies 364–70, 373–6
  product development in industry 348–64
Area of Study 3 (Unit 3), designing for others – creating a folio 390–404
Area of Study 1 (Unit 4), product analysis and comparison 377–88
Area of Study 2 (Unit 4), product manufacture 405–8
Area of Study 3 (Unit 4), product evaluation 409–11
Art Deco 294, 319–20
Art Nouveau 292, 318–19
  designers 319, 320
art styles or movements, researching 270
Arts and Craft movement 318
  designers 318
assembly (timber) 173–81
assembly tools 176
asymmetry 77
attaching interfacing 229
attributes 378
attributing intellectual property (IP) in your folio 27, 111, 113, 247, 280, 393
Australian design innovations 328–31
Australian fashion design 304–14
Australian furniture design 325–31
Australian Furniture Research and Development Institute (Furntech–AFRDI) 130
Australian Standards 112–13
authentication 46

B

B Corporations 131
back sawing 162
bag, application of product design factors to a 248–50
balance and proportion 76–7
Balenciaga 298
Ballets Russes 293
bamboo 160, 216, 223
bamboo clothing, case study 238–40
banknotes 349
Bannister, Jenny 306–7
bar charts 26
Barrell, Emily, master embroiderer (case study) 241–2
basting/tacking 228
batik 236, 314–15
Bauhaus 321
  designers 321
beading 237
beating metal 188
Belle Époque 292
bending 143
  metals 187–8
  plastics 199
  timber 168, 169
bespoke 211
between centres (lathes) 167
bill of materials 43
Bima Wear 315
biological attack resistance 150, 156
biomimicry 354
Biomorphism 322, 325

9780170400336

biscuit cutters 175
Blackmagic Design 368–70
blends 215
block printing 235
blow moulding 201
body measurements 73, 226–7
body size and shape 101
body templates 70–1
Bodypeace: bamboo clothing (case study) 238–40
bolts 189, 190
bonded fabrics 220–1
box, shelf and cabinet joints 170–1
brainstorming 276
brazing 191
Britax Baby Safety Capsule 330
Büro North: the Büro tree – product design and wayfinding (case study) 131–3
butt joints 170

C

cabinet joints 170–1
cabinet oblique 61
calendering 200
Cantilever: environmental thinking in practice – cabinetry (case study) 135–8
Carbon Trust 131
carcase joint 171
Cardin, Pierre 298, 300
care labelling 410, 411
carving 83, 178
case studies
  Bodypeace: bamboo clothing 238–40
  Bryan Cush, Sawdust Bureau 203–6
  Büro North: the Büro tree 131–3
  Cantilever: cabinetry 135–8
  Charlwood Design 342–4
  Emily Barrell: master embroiderer 241–2
  Etiko: ethical clothing, etc. 133–5
  FOOL clothing 243–4
  Jacki Staude, metalworker 206–9
  Jim Hannon-Tan: product designer 373–6
  Marc Pascal: industrial designer 364–8
  Marcos Davidson – jewellery and other products 209–13
  Rip Curl: wetsuit development 272, 275, 286–90
  Schamburg + Alvisse 264–7
  Steve Martinuzzo from Cobalt Design 344–7
  Tim Garrow 368–70
  Valentino's Resort range, 2016 285–6
casting
  metals 192
  plastics 201
catalysts 199
cavalier oblique 61
cement 141
ceramics, classification subgroups 141
Cerini, Nicola 6–7
certification 130, 223, 386
Chanel 294, 297
characteristics and properties (materials) 16, 91, 114–16, 141
  non-resistant materials 147–51
  resistant materials 144–7
Charlwood Design (case study) 342–4
chasing 193
chemical finishes (fabrics) 220
chemical resistance (non-resistant materials) 149, 156
chipboard 161
chiselling 167
choosing products 377
  in real life 378
chuck 167
circular economy 106
clamping and gluing 173–4
clamping tools 176
clarity, text and images 49–50
classifying materials 140–2
client 3
closed loop 106
clothing
  body measurements 73, 226–7
  case studies 133–5, 243–4
  colour 85
  computer-aided design 73
  construction drawings 71–2
  environmental design strategies 125
  'flats' 35, 71, 401
  forms of drawing 68
  lines 86
  modelling and trialling ideas 74
  patterns, sizing and layouts 73
  patterns in design 87–8
  presentation drawings 69–71
  production stages 224–34
  shape, proportion and balance 84–5
  styles 88–9, 292–304
  texture of fabric 86
  visualisations 69
  working drawings 71–3
  see also fashion; fashion design; fashion styles
CNC (computer numerical control) 352
CNC routers 168
coated metals 183
Cobalt Design (case study) 344–7
collaboration 268
  see also teams; teamwork
collaborative design 268–85
colour
  clothing 85
  in design 78–9
  furniture 82–3
  metals 84, 194
  to enhance drawings 63
colour blocking 85
comfort 101
commercial patterns, modifying 72
comparing products 386–7
  by their specifications 385
  using criteria for testing and comparing 387–8
compatibility of materials 115
  and proximity 115–16
components 125
compression (force) 143
compression moulding 200
computer-aided design (CAD) 351
  and CNC routers 168
  garments 73
  pattern-making programs 73
  resistant materials 66–7
computer-aided manufacturing (CAM) 351–2
computer numerical control (CNC) 352
concept maps 22, 256
condensation polymerisation 195
considerations 9, 13–16
  content for 14–16

9780170400336

consistency (testing procedure) 151
constraints 9, 13–16
  content for 14–16
construction drawings 71–2
consumer use 356
content (design folio) 50
context 14, 96, 379
continuous production 363, 364
contrast 79
convergent thinking 52, 53, 276
conversion techniques 116–17
copyright 109
  in your folio 112
Copyright Amendment (Moral Rights) Act 2000 111
corporate social responsibility (CSR) 129
corrodibility 146
corrosion resistance tests 154
cost factors 15, 91, 107, 381
cotton 216
  production 222, 223
'cradle to cradle' concept (C2C) 359, 360
crating 61
creative thinking 52, 53–4
  in teams 276
  techniques 55
  using triggers to be creative 55–6
creativity 15, 53, 102
  in your folio 50–1
creep 142
critical thinking 52, 53, 54, 257
  in teams 276
  techniques 55
crosscutting 166, 167
CSIRO 349
  innovations 349–50
cultural styles, movements and genres 291–2
culture and religion 96–8
curing (thermosetting plastics) 199
Cush, Bryan, Sawdust Bureau (case study) 203–6
cutting
  fabrics 227–8
  metals 185
  plastics 198
  timber 166–9
cyclic loading 142

D

dado joints 170
dangerous machinery 406
datum line 184
Davidson, Marcos, jewellery and other products (case study) 6, 209–13
de Bono, Edward 54
De Stij 321
decision matrix 32–3
Décor BYO wine cooler 330
decorative processes
  fabrics 234–7
  metals 193–4
  plastics 202
  timber 178–9
deflection 144
deformation 144
deforming load 144
degradable plastics 197
density 145
descriptive drawings 69–70
design
  'good', what is it? 3
  importance of 356
  and sustainability 359
  teamwork in 272
  what is it? 2
design aesthetics 74–81, 381
design and development (conceptualisation of ideas) 9, 28–35, 269, 355
  designing for others 395–402
  product redevelopment 257–9
  team approach 280–3
  types of drawings and their purpose 29–35
  using graphic organisers 26
design brief 9, 12, 337, 392
  annotations 18, 341
  attributing IP 113
  constraints and considerations 13–16
  constructing and annotating 339, 340
  economic factors 108
  evaluation criteria 19–21, 255–6, 278–9, 337, 340, 393
  innovation and creativity 103
  making connections to research 23
  materials 116
  OH&S guidelines 113
  outline of the context 12–13
  Product Design Factors 14–16
  product redevelopment 254–5
  purpose, function and context 96
  quality indicators 17
  setting out your 16–17
  standards 113
  sustainability requirements 107
  technologies available 118
  to direct activities 340–1
  user-centred design approach 102
  visual, tactile and aesthetic factors 104
  writing 254–5, 277–8, 337
design elements 74
design elements and principles 74–81
  fashion and clothing 84–9
  resistant materials 81–4
design folio 49
  attributing moral rights and IP 27, 111, 113, 247, 280, 393
  clarity 49–50
  content 50
  copyright issues 112
  impact and creativity 50–1
  see also designing for others – creating a folio
design for disassembly (DfD) 124, 125, 359, 360
design innovations, Australian 328–31
design inspiration 291–331
design option development (exam section B) 421
  choosing your product 421–2
  drawing production processes 423–4
  explaining and expanding on your design idea 424
design options 30, 281, 398–400
  annotations 30–1
  evaluation criteria 19, 32
  feedback from others 32
  justifying the preferred option 33, 258–9, 293, 400
  product redevelopment 258–9
  selecting the preferred option 32–3, 258, 282, 398
  using a decision matrix 32–3
  using ICT 398

design principles 74
design problem 10
design process stages *see* Product Design Process stages
design registration 109
  fashion 110
  industrial objects 110
design styles, researching 270
design thinking 52–3
  creative and critical thinking 53–6
  student drawings 58
  using mood boards 56–7
designer/end-user relationship 336
  designer's role 335–6
  end-user 336
designers 3–4
  different fields, different perspectives 7
  how they work 5–7
  what do they do? 4, 335
  see also under specific eras, e.g. 1970's or styles, e.g. Art Deco
designing for end-user/s 335–42, 416
  case studies 342–7
  design brief and evaluation criteria 337
  designer/end-user relationship 335–7
  examinable content and revision activities 416
  preparation for the SAT 342
  researching needs and gathering ideas 337
designing for others – creating a folio 334, 390–404
  design and development 395–402
  end-user 390–1
  investigating and defining 391–5
  planning and production 402–4
designing products
  cultural and religious considerations 97
  environmental strategies 124–5
detail drawing 65–6
developing a product design (exam Section B) 421
  developing a design option 421–4
  explaining and expanding on your design idea 424–5
  questions before drawing your design option 421
digital printing 235
  see also 3D printing
digital technologies 398, 402
  use in a team 275
  see also computer-aided design (CAD); computer-aided manufacturing (CAM)
dimensions on drawings 66
Dinnigan, Collette 310–11
Dinosaur Designs 311–12
Dior 297
distribution 356, 360
divergent thinking 52, 53, 276
documenting production 46–7, 284, 407–8
domino cutters 175
dovetail joints 171
drape (fabric) 150
  tests 157
drawing and design
  with non-resistant materials 68–74
  with resistant materials 59–68
drawings
  dimensions on 66
  types of 29–35, 59
  see also presentation drawings; visualisation drawings; working drawings
drilling, metals 186
drills and drill bits, timber 174
dry check/dry run (timber assembly) 173
ductility 145
  tests 153
durability 146, 148
  designing for 125, 126
  tests 153, 155
dye absorption and retention (fibres) 150
  tests 156
dyeing 236

E

ease of machining 146
  tests 154
eco-design 124, 223
economic status
  designs for average incomes 98
  designs for impoverished communities 98
  designs for wealthier communities 98
economic sustainability 105, 120, 129
economics, time and cost factors 15, 91, 107, 249
eco-printing 235
edge joints 169–70
edging (fabrics) 232–3
elastic deformation 142
elasticity 144, 148, 151
  tests 153, 155
electric arc welding 192
electrical conductivity 145
  tests 154
electrical and electronic products, environmental design strategies 125–6
elevations 63, 64
embodied carbon 127
embodied energy 125, 126–7
embodied water 126
embroidery 236–7
  case study 241–2
emotional and sensory appeal 99
emotional attachment to products 106–7
enamel paints 194
enamelling 193
end-products 45
end-users 336
  designing for 335–42, 416
  identifying 10–11
  instructions and/or care requirements 410–11
  profiles 11–12, 392
  Unit 3, Area of Study 3: designing for others 390–1
  see also users
end view 64
energy efficient design 125
engraving 179, 193, 202
environmental certification 130, 223, 386
environmental design frameworks and concepts 126–7
environmental design strategies 124
  for electrical and electronic products 125–6
  for fabric and fashion 125
  for resistant materials 125

environmental impacts 121
depending on the type of product 123
fabrics and fibres 223–4
forest logging 122, 164–5
life cycle analysis/assessment 123–4
plastics 197–8
sourcing and processing metals 183–4
stages of a product's life 122–3
environmental protection laws 130
environmental regulations, standards and certification 129–30, 223, 386
environmental sustainability 105, 120, 121–7, 164–5, 358–9
epoxy resins 201
ergonomic design 15
ergonomics 10, 101–2, 380
Esky 329
etching 193, 194
Ethical Clothing Australia 131
ethylene dichloride 202
Etiko: ethical clothing, shoes and sporting equipment (case study) 133–5
evaluation criteria development (design brief) 19, 337, 393
constructing from the brief 340
for design option drawings 19, 32
for the finished product 19–21
product redevelopment 255–6
team approach 278–9
evaluation of the finished product (or prototype) 9, 48–9, 269, 284
and modification 356
redeveloped product 263
storage unit (example) 48
suggestions for improvement 49
Unit 4, Area of Study 3 409–11
evaluation report 409–10
examinations
content 412
equipment for your exam 413
key concepts for assessment 414–20
knowing your terminology 425–6
preparing for section A 420–1
preparing for section B: developing a product design 421–6
structure 413
useful question terminology 413
existing products
analysing sustainability 252–3
how does it appeal to the senses? 251
what is it, who is it for and what does it do? 250–1
extended producer responsibility (EPR) 359, 360
extension lines 66
extrusion 200

F

fabric printing and painting, by Indigenous Australians 314–15
fabrics 214
choosing for sustainability 253
construction 219–20
patterns formed 87
decorative processes 234–7
environmental design strategies 125
finishes 220
patterned 88
pre-washing 225
processes for working with 224–37
production stages 224–34
properties and forms 218
quality 222
shapes to pattern 85
with special characteristics 220–2
texture 86
see also clothing; non-resistant materials; yarns
Fairtrade accreditation 128, 130, 386
Fairtrade Labelling Organisation (FLO) 130
fashion
colour 85
design registration 110
environmental design strategies 125
shape, proportion and balance 84–5
and trends 100
using design elements and principles 84–9
see also clothing
fashion design, Australian 304–14
fashion drawings 70
fashion forecasting 100
fashion ideas, modelling and trialling 74
fashion illustrations 69
fashion styles 88–9, 292–304
1900s 292–3
1910s 293–4
1920s 294
1930s 294–5
1939–45: World War II 296
1947–57 297–8
1957–67: 'Swinging Sixties' 298–9
1970s 299–300
1980s 301–3
1990s 303–4
fatigue 142
Featherston, Grant and Mary 6, 326–7
feedback from others 32
felt and felting 219, 220, 237
ferrous metals 181, 182
FEWTEL (timber preparation) 165
fibre blends 215
fibre optics 352–3
fibres 116, 214
characteristics and properties 147
classification 215
dye absorption 150
forms of 117
length of 215
processing 217
properties, uses and forms 216
quality 222
and resins (plastics) 201
types of 215
see also clothing; non-resistant materials
figurative patterns 88
figuring 83
filaments 215, 217
finish types and uses (timber) 180–1

9780170400336

finished product
evaluation 48–9
evaluation criteria (design brief) 19
finishing and edging (fabrics) 232–3
finishing wood surfaces 179–81
finite resources 121
fishbone diagrams 23
fit for purpose 14–15
flapper style 294
'flat' drawings for non-resistant materials 35, 71, 401
flax/linen 216
flexible and responsive manufacturing 362
flux 189, 191
foaming 200–1
focus groups 336
folio *see* design folio
FOOL clothing (case study) 243–4
forces and effects (resistant materials) 142–4
forest logging 122, 164–5
Forest Stewardship Council (FSC) certification 130, 165, 386
form 76
fossil fuels 121
framing joints 172
free embroidery 237
fretwork 179
front elevation 64
full-cost accounting 129
function 2, 14, 96
primary and secondary 92–3, 96, 379
functional obsolescence 361
functionality 93–4
furniture
colour 82–3
patterns 83–4
shape and proportion 81–2
see also wooden furniture
furniture design 316
Art Deco 319–20
Art Nouveau 318–19
Arts and Craft movement 318
Australian 325–8
Bauhaus 321
Biomorphism 322, 325
De Stij 321
Industrial Tech 325
International Modernism 320–1
Japanese style 317
Memphis group 323
mid-century modern (1950s and 60s) 322–3
Organic Design 322, 325
Postmodernism 324
Scandinavian design 322
Shaker furniture (late 19th century) 316–17

G

Gantt chart 38
garments *see* clothing
Garrow, Tim, product engineer at Blackmagic Design (case study) 368–70
gas welding 191
general safety 40
geometric shapes 75, 81
Givenchy 298
Glam rock 300
glass
classification subgroups 141
patterns 84
gluing and clamping 173–4
golden mean 76
'good' design, what is it? 3
Good Environmental Choice Australia (GECA) 131
Gore-Tex® 220–1
'grade' patterns 73
Grant, Martin 5, 88, 307–8
graphic organisers 277
for Area of Study 1 341
for design and development 28, 257, 395
to plan and manage research 22–3, 393
Great Depression 294
greenwashing 127, 253
Griffin, Marion Mahony 318, 326
Griffin, Walter Burley 318, 325–6
grinding 187
grunge 303

H

hallmarks 110
halving joints 172
hand embroidery 236
Hannon-Tan, Jim, product designer (case study) 373–6
hard attributes 378
hard soldering 189
hard-spun yarns 218
hardening (metals) 188
hardness 144
tests 153
hardwoods 158–9
cell structure and cross-section 160
commonly used 160, 163
hatching 63
Health and safety (OH&S or WHS) 41, 113
metals 183, 185, 186, 187, 191, 194
plastics 196, 202
textiles 222, 234
wood and wood products 164, 166, 167, 168, 175, 181
heat resistance 145
heat treatment, metals 188
hemp 223
hidden detail drawing 65
high-end fashion
1970s 300
1980s 301
hollowware 209
horizon line (HL) 62
housing joints 170

I

idea formulation 29–30
identifying the need 10–12, 355
ways of 11–12
images, clarity 49–50
impact of your folio 50
inclusive design 99
Indigenous Australians
designing products for 97
fabric printing and painting 314–15
misappropriation of their artwork 97
possum-skin cloaks 316
textiles 314–16
industrial design, registration 110
industrial designers, case study 5, 364–8
Industrial Tech 325
industrial tools and processes 178, 193, 199–201, 234
information, research for 21, 22, 23, 25, 26, 256, 393
injection moulding 200

9780170400336

innovation and creativity 15, 53, 91, 102–3, 248
  Australian companies, designers and product design 328–31
  in product development 357
innovation patents 109
inputs 123
insertions and additions (fabrics) 231–2
inspiration
  design 291–331
  through research 21–2, 24, 256, 393
installation 16
instructions and/or care requirements 410
integrated circuits (ICs) 353
intellectual property (IP) 108, 247, 249, 292
  attributing 27, 111, 113, 248, 280, 393
  protecting your 111
  types of 109–11
  what is IP infringement? 111
  what is it? 108–9
interlocking joints 171
International Modernism 320–1
  designers 321
International Organization or Standardization (ISO) 112, 130
International Standards 112, 113, 130
interviews 11, 391
invention 103
investigating and defining the need 9–28
  design brief 12–18
  designing for others 391–5
  developing evaluation criteria 19–21
  identifying the need 10–12
  research 21–8
  teams 276–80
ISO 9000 Quality Management 113, 130, 386
ISO 14000 Environmental Management System 130, 386
ISO 26000 Social Responsibility 130
Isogawa, Akira 5–6, 308–9
isometric drawing 62

J

Jackson, Linda 305–6
jacquard 218, 219
Japanese style furniture 317
jewellery making, case study 209–13
joining metals with bolts, screws and rivets 189–90
joining seams 230–1
joints (timber) 169–72
journal documents 46, 284, 407
  noting modifications 46–7
  sample layout 46
just-in-time (JIT) 362
justifying the preferred option 33, 258–9, 283, 400

K

Kambrook Axis Eco Kettle 330
Kambrook power board 329
Kee, Jenny 305–6
Keep Cup Brew 331, 346–7
knitted fabrics 218, 219
knock-down fittings 176–8

L

laminated fabrics 220–1
laminating
  plastics 202
  timber 168, 169
landfill 121
laser cutting 202
laser technology 350–1
lateral thinking 54
lathe techniques
  metals 186–7
  wood 167
layout 72
lean manufacturing 362
legal responsibilities 16, 91, 108–13, 249
lemon squeezers
  primary and secondary functions 379
  using criteria to compare 388
length of fibres 215
life cycle analysis/assessment (LCA) 123–4, 358, 359, 360
life cycle thinking 124
lines 24–5
  garments 86
live sawing 162
log (journal) 46, 284, 407–8
logging (forests) 122, 164–5
low-impact fabrics 125
low-volume production 363
Ludlow, Hall 304–5

M

machine embroidery 236
machining, plastics 201
Mackintosh, Charles Rennie 318
malleability 144
mandatory standards 112–13
mandrel 213
manual handling guidelines 40
manufactured boards 161, 162, 163
manufacturers
  priorities 382–3
  values of 'new' and 'older' products 383–4
manufacturing 360
  R&D role 348–50
  scales of 362–4
  see also product manufacture
manufacturing processes used in industry 403–4
  metals 193
  plastics 199–201
  textiles 234
  timber 178
manufacturing systems, types of 362
maquette 262
market-led designs or opportunities 10
market research 11, 336–7, 357–8, 385, 391
marketing 360
marketing elements 357–8
marking, fabrics 228
marquetry 179
Martinuzzo, Steve, Cobalt Design (case study) 344–7
masonite 161
mass (high-volume) production 363, 364
Materia 142
Material ConneXion 142
materials
  aesthetics 115
  characteristics and properties 16, 91, 114, 141, 250
  classifying 140–2

9780170400336

compatibility 115–16
conversion techniques 116
environmental design strategies 125
forms of 117
images or samples 27
knowledge of 261, 279–80, 403
new 353
online library 142
purchasing 118
source (sustainability) 127
suitability 114–15
see also non-resistant materials; resistant materials
materials and costing list 43–4, 283
materials and notions list 43
materials cutting list 43
materials test report 152–3
materials testing 151, 261
elements of successful testing 151–2
tests for non-resistant materials 155–7
tests for resistant materials 153–4
measurements
clothing 73, 226–7
fabric 234
measuring and marking tools 165, 184, 224
mechanical finishes (fabrics) 220
mechanical properties (resistant materials) 144–5
medium density fibreboard (MDF) 161, 164
membranes 218
Memphis group 323
designers 324
metal workrooms, risk assessment and management for safety 40
Metalicus 5
metals
choosing for sustainability 254
classification 181
classification subgroups 141
colouring 82, 194
decorative treatments 193–4
environmental issues 183–4
forms of 117
general properties 181
health and safety issues 183, 185, 186, 187, 191, 194
industrial tools/processes 193, 403
origin and properties 181–4
patterns 83
preparation 184
processes for working with 184–93, 405
processing and production (from raw materials) 182
quality of materials 183
surface finishing 194
and their uses 182–3
see also resistant materials
metalworker, case study 203–6
Mexican oilcloth 221
microchips 353
microfibres 215
mid-century modern (1950s and 60s) furniture 322–3
designers 323
MIG welding 192
milling machine techniques 187
mind maps 341
mining, environmental issues 184–5
misappropriation of Aboriginal art 97
mitre joints 171
models and modelling 45
non-resistant materials 74
resistant materials 67
modifications to designs or plans during production 46–7
moisture absorbency 148–9
tests 155
moisture content (porous materials) 145
mokume 83
monomers 195
mood boards 56–7, 281
moral rights
attributing other's work in your folio 111
Copyright Amendment (Moral Rights) Act 2000 111
Morris, William 318
mortise and tenon joints 172
movement and rhythm 80
movements (design or art), researching 270–1, 292

N

nail types and uses 175
nano-engineering 354
natural fibres 215, 222
processing 217
naturalistic patterns 88
need
identifying the 10–12
perceiving through personal experience 10
to improve something ergonomically 10
negative space 77
new and emerging technologies 350–4
new materials 353
'new' products, manufacturer and user values 383
New Romantics style 302
Newson, Marc 6, 327–8
non-ferrous metals 181, 183
non-resistant materials 140, 147
case studies 238–44
characteristics and properties 147–51
classification subgroups 141
computer-aided design 73
construction drawings 71–2
'flat' drawings for 35, 71, 401
modelling and trialling ideas 74
presentation drawings 69–70, 69–71
production steps 37
suitable forms for drawing 68
suitable media for drawing 68
testing for properties 151
tests 155–7
visualisations 69
working drawings 71–3
see also fabrics; fibres; textiles; yarns
non-woven fabrics 218, 219
notions 43, 125
numerical research, presenting visually 25–6
nuts 189–90
nylon 216

O

oblique drawing 61
obsolescence
planned 360–2
what is it? 360

occupational health and safety (OH&S) *see* Health and safety (OH&S or WHS)
Oeko-Tex® Standard 100 223
'older' products, manufacturer and user values 384
one-off manufacturing 363, 364
one point perspective drawing 62
Op Art 298
opacity 115
open-ended brief 103
operation and performance 14, 94, 248
Organic Design 322, 325
organic shapes 75–6, 81
orthogonal drawings 63–4, 401
outdoor table
  production steps 37
  timeline (Gantt chart) 38
outline of the context 12
  for broad end-users 13
  for end-users in a target group 13
  for one end-user 13
outputs 123–4
outsourced technologies 118
overlockers 229

P

palladium 210
Pascal, Marc, industrial designer (case study) 5, 364–8
patchwork 237
patents 109, 110
pattern adjustments 225
pattern blocking 224
pattern drafting 35, 224, 401
pattern layout 225
patterned fabrics 88
patterns
  in clothing or fabric product design 87–8
  formed in fabric construction 87
  furniture 83–4
  printed 87–8
  and rhythm 80
  and shapes in fabrics 85
  sizing and layouts (garments) 73
people 260
perceiving a need through personal experience 10
performance and operation 14, 94, 248
personal protective equipment (PPE) 39
perspective drawing 62
petrochemicals 195, 197
physical properties (resistant materials) 145–6
pie charts 26
pierced designs (sheet metal) 193
Pierre Cardin 298, 300
place 357–8
plan view 63, 64
planing 166
planish 213
planned obsolescence 360–2
planning (materials test) 152
planning and production 9, 36–47, 269
  modelling 45
  product redevelopment 259–62
  production 45–7
  scheduled production plan 36–44, 283, 402
  team approach 283–4
  Unit 3, Area of Study 3: designing for other 402–4
plantation timber 165
plasma cutting 185
plastic deformation 142, 144
plastic rubbish 197
plasticity 144, 151
plastics
  choosing for sustainability 254
  classification subgroups 141
  colour 82
  decorative processes 202
  environmental issues 197–8
  finishing 202
  forms of 117
  general properties 195
  health and safety issues 196, 202
  industrial manufacturing processes 199–201, 403
  joining 201–2
  origins and properties 194–8
  processes for working with 198–202, 406
  production process 195–6
  quality of materials 196
  recycling 198
  symbols for different types 198 and their uses 197
  see also resistant materials
plastics workrooms, risk assessment and management for safety 40
plywood 161
point 79
polyester 216
polyester resins 201
polymers 194, 195, 197
Pop Art 298
Pop design 322
pop riveting 190
porosity 145
positive space 77
possum-skin cloaks 306
Postmodernism 324
  designers 324
power dressing 301
preferred option
  feedback from others 32
  justifying 33, 258–9, 283, 400
  selecting 32–3, 258, 282, 398
presentation drawings 29, 59, 61–3
  for design options 30–3, 258–9, 398–400
  non-resistant materials 69–70
  product redevelopment 258–9
  resistant materials 61–3
pressing and steam tools 234
Preston, Johanna 5
pre-washing fabric 225
price 357
primary functions 92, 93, 96, 379
primary need 12
primary sources of information 25, 279, 337–8
printed patterns 87–8
printing from nature 235
printing (on fabric) 234–5
prioritising product attributes 382
  user, manufacturer or designer? 382–3
  values vary and change 383–4
processes
  for working with metals 184–93, 405
  for working with plastics 198–202, 406
  for working with textiles 224–7, 406
  for working with timber 165–81, 405

9780170400336

product analysis and comparison 377–88
examinable material and revision activities 419–20
product attributes 378
cost/value 381
prioritising 382–4
purpose, function and context 379
quality 382
sustainability 381–2
user-considered design 380
visual, tactile and aesthetics 381
product design factors 14–16, 90–1, 247, 270, 335, 389
applying (to a bag) 248–50
economics – time and cost 15, 91, 107–8, 249
examinable content and revision activities 415–16
highlighting 340
innovation and creativity 15, 91, 102–3, 248
intellectual property (IP) 108–11, 247, 249
legal responsibilities 16, 91, 108–13, 249
materials – characteristics and properties 16, 91, 114–16, 250
and product attributers 378
purpose, function and context 14–15, 91, 92–6, 248
storage, transportation and installation 16
sustainability 15, 91, 104–7, 249
technologies – tools, processes and manufacturing methods 16, 91, 116–18, 250
user-centred design 15, 91, 96–102, 248
visual, tactile and aesthetics 15, 91, 103–4, 248
product design process 247, 334–5, 389
design and development 9, 28–35
evaluation 9, 48–9
examinable content and revision activities 414–15
investigating and defining 9–28
planning and production 9, 36–47
team approach 269–70
product development, as a team 273–4
product development in industry 348–64
examinable content and revision activities 417–19
importance of design and innovation 356–7
market research 357–8
new and emerging technologies 350–4
product development process 354–6
product obsolescence 360–2
R&D role in manufacturing 348–50
scales of manufacturing 362–4
sustainability models 358–60
types of manufacturing systems 362
product development process (mass production) 354–5
concepts or identifying a need 355
design and prototype development 355
product evaluation and modification 356
production and distribution 356
research 355
retail and consumer use 356
product disposal 125, 128
product evaluation 409–11
care labels 410, 411
evaluation report 409–10
instructions for use or repair 410
see also evaluation of the finished product (or prototype)
product evaluation methods 384–6
certification 386
comparing specifications 385
market research 385
sales and returns 385
user trials and testing 385
product manufacture
making your product 405
processes 405–8
recording your progress 407
product range 274
product range development, as a team 274
product redevelopment *see* redeveloping a product
product returns 385
product specifications 9, 33–5
product stewardship 130, 359
product use 125, 128
production 45–7, 356, 360
documenting 46, 47
environmental design strategies 125
of materials and products (sustainability) 128
modifications to designs or plans during 46–7
prototype or ‘end-product’? 45, 261–2
team approach 284
production line product development, as a team 274
production steps 36–7, 260, 283
for an outdoor table (example) 37
for textiles 37
product(s) 357
how we choose 377–8
product’s life stage, environmental impact 122–3
products that have been around for a while, manufacturer and user values 384
promotion 358
properties of materials 114
proportion
and balance 76–7
furniture 81–2
prototypes 6, 7, 45, 261–2, 355
evaluation 48–9
wood, metal and plastics products 67
proximity of materials and compatibility 115–16
punk 302
purpose, function and context 14–15, 91, 92–6, 248, 379

Q

qualitative information 384, 385
quality checks 44, 95
quality control 44
quality indicators 17
quality measures 44, 260–1, 283
quality of materials
fibres and fabrics 222

metals 183
plastics 183
quality of the product 14–15, 94–5, 382
concept map 95
quality production 406–7
Quant, Mary 299
quantitative information 384, 385
quarter sawing 162
quenching 188
quilting 237

R

radical innovation 102
rapid prototyping 352
Rashid, Karim 6
reaction to chemicals (non-resistant materials) 149
tests 156
rebate joints 170
record keeping (testing) 152
recording your progress 46–7, 284, 407–8
recycling 125, 198
redeveloping a product
analysis 250–2
comparison with the original product 263
design and development 257–9
evaluation 263
planning and production 259–62
research 256–7
writing the design brief 254–5
writing the evaluation criteria 255–6
regenerated fibres 217
reliability 94
religion and culture 96–8
remanufacturing and material recovery 126
rendering 63
repairable products 125, 126, 410
repeatability (material testing) 152
repoussé 193
reproduction 292
research 21, 269, 337, 355, 393
annotation 28
attributing intellectual property (IP) and acknowledging your sources 27, 111, 113, 247, 280, 393
collaborative design 277
from primary and secondary sources 25, 279, 337–8
graphic organisers to plan and manage 22–3
how much to include? 23
images or samples of materials 27
for information 6, 21, 22, 23, 25, 256, 393
for inspiration 21–2, 24, 256, 393
making connections from design brief to 23
presenting numerical research visually 25–6
presenting your 280
product redevelopment 256–7
research and development (R&D)
CSIRO role 349–50
forms of 348–9
role in manufacturing 348–50
what is it? 348
researching, styles or movements 270–1, 277, 292–331
resistance to biological attack 150
tests 156
resistant materials 140
case studies 203–13
characteristics and properties 144–7
computer-aided design 66–7
design elements and principles 81–4
environmental design strategies 125
forces and effects 142–4
presentation drawings 61–3
suitable forms for drawing 60
suitable media for drawing 60
technical drawings for 34
tests 153–4
visualisations 59–61
working drawings 63–6
see also metal; plastics; timber(s); wood
Restriction of Hazardous Substances Directive (RoHS) 129
retail and consumer use 356
rhythm
and movement 80
and pattern 80
rigidity 144
Rip Curl: wetsuit development (case study) 272, 275, 286–90
ripping 166, 167
risk assessment 39, 41, 260, 283
chart 42
risk assessment and management for safety 39
manual handling guidelines 40
textile workrooms 39
wood, metal and plastics workrooms 39–40
risk control, at different stages of product production or use 42–3
risk management 39, 40–1
riving knife 167
robotics 351
roller printing 235
Romance Was Born 313–14
routers 168
ruffles 237
rupture 142

S

safety 15, 39–43, 100, 380
manual handling 40
resistant materials 39–40
risk assessment and management for 39–40
test procedures 152
textiles 39
safety data sheets (SDS) 43, 164
Saint Laurent, Yves 298, 300
sales and returns 385
SAT
overview 390
Unit 3, Area of Study 3: designing for others – creating a folio 334, 390–404
Unit 4, Area of Study 2: product manufacture 405–8
Unit 4, Area of Study 3: product evaluation 409–11
Sawdust Bureau (case study) 203–6
sawing
metals 185
timber 162, 166–7
scales of manufacturing 362–4
SCAMPER 56
Scandinavian design 322
designers 322
Schamburg + Alvisse (case study) 264–7

scheduled production plan 36–44, 283, 402
materials list and costing 43–4, 283
production steps 36–7, 283
quality measures 44, 283
risk assessment and management for safety 39–43, 283
timeline as a Gantt chart 38, 283
schematic drawings 211
screen printing 234, 315
screw types and uses
metal 189
timber 175–6
seams, joining 230–1
secondary functions 92, 93, 96, 379
secondary sources of information 25, 279, 338
section drawing 66
selecting the preferred option 32–3, 258, 282, 398
selvedge edge 225
sensory appeal 99
sequenced plan of construction 36–7
serviceable products 126
sewing machines 229–30
sewing tools 229–30
Shaker furniture (late 19th century) 316–17
shapes 75–6
experimenting with 81–2
furniture 81–2
garments, outfits or accessories 84–5
to pattern fabrics 85
shaping
metals 193
plastics 198–9
timber 166–9
shear forces 143
shear plane 143
sheen 79
shelf joints 170–1
shibori 236
shrinkage (non-resistant materials) 150
tests 156
silhouette 84
silk 216, 217
Six Sigma 362
size 15
sketching objects and design ideas 60
skins 218
smart electronic fabrics 221
smart yarns 221
smelting 184
social and physical needs 100
social sustainability 104, 120, 127–9
soft attributes 378
soft soldering 189
soft-spun yarns 218
softwoods 159
cell structure and cross-section 160
commonly used 160, 163
soldering 189
soybean fibre 223
specification sheets 71
spinnerette 217
spinning (sheet metal) 187
Sportwool® 221, 350
stained or coloured patterns (timber) 179
stains, applying (timber) 180
stakeholders 129
standardised parts and add-on connections (electronics) 126
standards 112, 130
Australian 112–13
international 112, 113, 130
mandatory 112–14
staple 215
statistical results, presenting visually 25–6
Staude, Jacki, metalworker (case study) 6, 206–9
stiffness 144
stitch-bonded fabrics 218
storage 16
Streamline 319
strength 144, 148
tests 153, 155
style obsolescence 361–2
styles 80–1
cultural 291–2
fashion 88–9, 292–304
researching 270–1, 292–331
'using' 292
sublimation printing 235
suggestions for improvement 49
suitability of materials 114–15
suitable forms
for drawing non-resistant materials 68
for drawing in resistant materials 60
suitable media
for drawing non-resistant materials 68
for drawing resistant materials 60
sunlight effects (non-resistant materials) 149
tests 156
supply chains 105–6, 128
surface finishes
metal 194
timber 180–1
surface marking (metals) 193–4
surface preparation (timber) 179
surface shaping (metals) 193
survey results
in a pie chart of bar chart 26
in a table 26
sustainability 15, 91, 104–7, 119–20, 249, 270, 277, 381–2
analysing, existing products 251–2
closed loop or circular economy 106
economic aspects 105, 120, 129
and emotional attachment to products 106–7
environmental aspects 105, 120, 121–7, 165, 358–9
global issues 120–1
social aspects 104, 120, 127–9
and the supply chain 105–6
sustainability in the classroom
all materials 254
metal 254
non-sustainable fibres 253
plastics 254
textiles 253
wood 254
sustainability models 123–7, 358–9
influence on design 360
influence on distribution 360
influence on manufacturing/production 360
influence on marketing 360

sustainable design case studies
Büro North: the Büro tree – product design and wayfinding 131–3
Cantilever: environmental thinking in practice – cabinetry 135–8
Etiko: ethical clothing, shoes and sporting equipment 133–5
sustainable development 119
United Nations Principles 128–9
sustainable practices by designers 253
sustainable product redevelopment (Unit 1) 246–63
'Swinging Sixties' 298–9
Sydney Opera House 7
symmetry 77
synectic thinking 55–6
synthesis 322
synthetic fibres 215, 217
environmental issues 222

T

tables, presenting results in 26
tactile qualities 15, 103
tailor's tacking 228
tame innovation 103
tap and die set 191
target market 255
teams
access to team documents 275
attributing IP 280
creative and critical thinking 275–6
design and development 280–3
digital technology use 275
evaluation report 284
investigating and defining the need 276–80
member responsibilities 275
planning and production 283–4
presenting your research 280
presenting your work 284–5
product design process 269–70
product development 273–4
product range development 274
production line product development 274
research based on primary and secondary sources 279
researching a style or movement 270–1, 277
setting goals 277
writing the design brief 277–8
writing the evaluation criteria 278–9
teamwork
approaches to 273–4
benefits of 272
in design 272
Rip Curl 272, 287
tear sheets 5
technical drawings for resistant materials 34
technical obsolescence 361
technologies
in the classroom 117
and conversion techniques 116–17
new and emerging 350–4
tools, processes and manufacturing methods 16, 91, 116–18, 250, 406
teenage fashion 298
tempering 188
tension (tensile force) 143
text, clarity of 49
textile workrooms, risk assessment and management for safety 39
textiles
health and safety issues 222, 234
Indigenous Australians 315–16
industrial processes and equipment 234
processes for working with 224–37, 406
properties 214–18
see also fabrics; fibres; non-resistant materials; yarns
textiles certification 223
texture 79
fabrics 86
texture shading 63
thermal conductivity (metals) 145
tests 154
thermal insulation, tests 155
thermal properties (non-resistant materials) 149
thermoplastics 195, 197, 199
thermosetting plastics 195, 197, 199, 200, 201
third angle orthogonal projection 63
threading 191
3D drawings 33, 34, 398
3D models 45, 67
3D printing 68, 352
design and copyright laws 109
in metal 192
321 Water bottle 331
through sawing 162
tie-dyeing 236
TIG welding 192
timber(s)
assembly 173–6
choosing for sustainability 254
classification 158
colour 82
common 163
cutting and shaping 166–9
decorative processes 178–9
environmental issues 122, 164
health and safety issues 164, 166, 167, 168, 175, 181
industrial processes 178, 403
joining techniques 169–72
moisture content and milling methods 161–2
patterns 83–4
preparation 165
processes for working with 165–81
processing and production 162
production 161
quality 164
sources 161
surface preparation and finishing 179–81
see also wood
time factors 15, 91, 108
timeline (Gantt chart) 38, 260, 283
tinted finishes 180
Tiwi Designs 315
toile 9, 74, 225, 262
tone shading 63
tools, equipment and machinery
knowledge of 406
see also specific types, e.g. sewing tools or specific applications, e.g. welding
torsion 143
total quality management (TQM) 362

9780170400336

toughness 144
Toyota Production System (TPS) 362
trade deficit 348
trademarks 109, 110
translucency 115
transparency 115
transportation of materials and products 16, 128
trees, structure and cross-section 159
triggers to be creative 55–6
triple bottom line 129
true-cost accounting 129
2D drawings 33, 34
two point perspective drawing 62

U

UN Basel Convention on movements of hazardous materials 130
unique selling point (USP) 107
Unit 1
  case study 264–7
  sustainable product redevelopment 246–63
Unit 2
  case studies 285–90
  collaborative design 268–85
Unit 3
  Area of Study 1 (SAC 1) 333, 335–42
  case studies 342–7
  Area of Study 2 (SAC 2) 334, 348–64
  case studies 364–70, 373–6
  Area of Study 3 (SAT) 334, 390–404
  product design factors 335
  product design process 334–5
Unit 4
  Area of Study 1: product analysis and comparison 377–88
  Area of Study 2: product manufacture 405–8
  Area of Study 3: product evaluation 409–11
United Nations, '10 Principles for Sustainable Development' 128–9
universal design 99
unsustainable products, impacts of 252–5
upcycling 126
upgradable products 126
user-centred design 15, 91, 96–102, 250, 277, 380–1
user trials and testing 385
users
  priorities (products) 382, 383
  values of 'new' and 'older' products 383–4
  see also end-users
utilitarian look 248, 296
Utzon, Jørn 7
UV protection 149–50

V

vacuum thermoforming 199
Valentino's Resort range, 2016 (case study) 285–6
values, and product's age 383–4
vanishing points (VPs) 62
viscerally 99
visual bulk 77–8
visual, tactile and aesthetic factors 15, 91, 103–4, 248, 381
visualisation drawings 29, 59, 271, 396–7
  for idea formation 29–30
  non-resistant materials 69
  product redevelopment 257
  resistant materials 59–61
  team approach 280–1

W

warp 87, 218
Waste Electrical and Electronic Equipment Directive (WEEE) 130
waste minimisation 125
water table 121
wayfinding 131
wear resistance, tests 154
wearable technology 221, 350
weft 87, 218
welding 191–2
wetsuit development, case study 272, 275, 286–90
wi-fi 349
wicking 149
widening joints 169–70
Wiltshire Staysharp knife 329
wood 158–81
  classification subgroups 141
  forms of 117
  general properties 158
  health and safety issues 164, 166, 167, 168, 175, 181
  origins and properties 158–65
  see also resistant materials; timber(s)
wood joints 169–72
wood products 163
wood workrooms, risk assessment and management for safety 40
wooden furniture, case study 203–6
woodturning 167
wool 216, 221, 222, 350
wool research 350
woollen fibres 215, 217
Work Health and Safety *see* Health and safety (OH&S or WHS)
working drawings 29, 59, 283, 400–1, 408
  non-resistant materials 71–3, 282
  product redevelopment 259
  for product specifications 33–5
  resistant materials 63–6
  using ICT 402
World War I 293
World War II 294, 296
woven fabrics 218, 219
Wright, Frank Lloyd 318, 325, 326
wrinkle resistance/recovery 151
  tests 157

Y

yarns 218
  characteristics 147
  see also fabrics; non-resistant materials
Yves Saint Laurent 298, 300

Z

Zly, Petr 5

9780170400336

nelsonnet

Register online at:

www.nelsonnet.com.au

to access digital resources to support improved learning & teaching*

Overview

- Exactly matches the 2018 Study Design
- Experienced authors who are active in the product design and technology community
- Case studies of local and inspirational young designers
- Smartphone revision cards to facilitate understanding
- Examples of how to use a range of design materials and technologies
- Recent student folio examples to showcase design development.

NELSON
A Cengage Company

*Please note that complimentary access to NelsonNet and the NelsonNetBook is only available to teachers who use the accompanying student textbook as a core educational resource in their classroom. Contact your Education Consultant for information about access codes and conditions.

ISBN 978-0170400336