Project Handbook

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Developed in the Faculty of Engineering and Information Technology at the University of Technology Sydney.

Original version was developed in the School of Civil, Environmental and Chemical Engineering at RMIT University.

Some materials were originally developed in the Department of Civil Engineering at Monash University.

Do let me know if this is of useful to you or if you would like to contribute.

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Overview

Engineers work on projects. Some projects are small and others large, but they all share some common characteristics, which we will explore in this handbook.

Engineers work with people. Engineering work requires teams of people to make it happen. So, it makes sense for projects at university to be done in teams.

Engineers persuade and negotiate. Although we often think that engineers "build stuff", what they really do is convince others to build the stuff according to their designs and directions. Hence, it's incredibly important that engineers be persuasive **communicators**.

Learning engineering through project work allows you to develop the full range of skills that an engineer needs in the workplace: project management, team skills, communication and problem solving. Since many of these take years to fully develop, you will find project work throughout your engineering program.

Key skills

The key skills in engineering projects are:

- **Understanding the problem** in all its complexity – social, environmental, economic and technical. This requires an understanding of **systems** and the definition of the **requirements**, which guide the next stage.
- The process of **engineering design and problem solving** (explore the problem, explore the alternatives, evaluate them against the requirements, choose and make a recommendation)
- **Project management** (organising engineering work and making sure that it happens, using quality and risk management in the process)
- Working as a **cohesive team**
- Organising **personal and group documentation** (e.g., a logbook and a design file)
- Preparing **public documentation** (a whole range of documents for various audiences)
- **Presenting** information to others and persuading them
- **Reflecting** on your work to learn and improve for future advantage.

All of these matters are the subjects of this handbook.

However, in order to keep it to a reasonable size, only a basic introduction is given here. Further information is available from:

http://project-handbook.pbworks.com

If you would like write-access to this site, to contribute to the handbook, please contact the Editor.

Engineering stage one competencies

Engineers Australia

Engineers Australia, the professional body for engineers in Australia, defines the competencies for graduating engineers – the Stage 1 Competency Standard (Engineers Australia 2017):

1. Knowledge and Skill Base

1.1. Comprehensive, theory-based understanding of the underpinning natural and physical sciences and the engineering fundamentals applicable to the engineering discipline.

1.2. Conceptual understanding of the, mathematics, numerical analysis, statistics, and computer and information sciences which underpin the engineering discipline.

1.3. In-depth understanding of specialist bodies of knowledge within the engineering discipline.

1.4. Discernment of knowledge development and research directions within the engineering discipline.

1.5. Knowledge of contextual factors impacting the engineering discipline.

1.6. Understanding of the scope, principles, norms, accountabilities and bounds of contemporary engineering practice in the specific discipline.

2. Engineering Application Ability

2.1. Application of established engineering methods to complex engineering solving.

2.2. Fluent application of engineering techniques, tools and resources.

2.3. Application of systematic engineering synthesis and design processes.

2.4. Application of systematic approaches to the conduct and management of engineering projects.

3. Professional and Personal Attributes

3.1. Ethical conduct and professional accountability

3.2. Effective oral and written communication in professional and lay domains.

3.3. Creative, innovative and pro-active demeanour.

3.4. Professional use and management of information.

3.5. Orderly management of self, and professional conduct.

3.6. Effective team membership and team leadership.

For a detailed discussion of these attributes, you should see (Engineers Australia 2017). All Australian university engineering programs are re-accredited by Engineers Australia (EA) every 5 years against these requirements.

Your sequence of project courses, combined with more specialised technical courses, is designed to help you to develop these graduate capabilities during your time at university.

We are **not** expecting you to have them developed already. We **are** expecting that you will **engage enthusiastically** in the process of developing these knowledge and skills through all your subjects. This is, hopefully, why you have come to university – to learn engineering.

Student Membership of Engineers Australia

Membership of EA is **free** to students.

Australian Computer Society

Outcomes needed here

IEEE and IET

Electrical engineering students should also see the IEEE (http://www.ieee.org) and IET (http://www.iet.org).

Institution of Chemical Engineers, UK (IChemE)

Chemical Engineering programs are usually also accredited by the the Institution of Chemical Engineers, UK.

You should visit http://www.icheme.org to find out about student membership.

International Engineering Alliance

Australia is a signatory to the *Washington Accord*, which provides cross-recognition of accreditation processes between developed nations. This means that your engineering degree will be recognised in the US, UK, Canada, NZ, Singapore, and several others, which makes it easier for you to gain international experience after you graduate.

See http://www.ieagreements.org for more information.

About Project-Based Learning (PBL)

Because engineers work in projects, engineering is best learned through projects (Prince and Felder 2006). This is usually called project-based learning (PBL), which is centred on the learning that emanates from a real engineering project. The *learning* is more important than the *solution* of the project.

In Project Based Learning, you will spend much of your time *learning* – by:

- identifying what you need to know,
- finding out (from the library, internet, colleagues, etc),
- teaching each other and then
- applying your new knowledge to the project.

Thus, the primary aim of the exercise is the *learning*, not the completion of the project. The project is the means to this end.

Project Based Learning encourages *independent and interdependent learning* and a deeper understanding of the material, rather than superficial coverage. It will give you practice in tackling engineering problems and defining your own gaps in understanding in the context of those problems.

Most importantly, you learn to tackle problems you haven't seen before. That is the nature of engineering practice.

Competency being developed

Engineers Australia (Engineers Australia 2017) expresses this competency for *lifelong learning* as:

3.5 Orderly management of self, and professional conduct.

a) Demonstrates commitment to **critical self-review** and **performance evaluation** against appropriate criteria as a primary means of tracking personal development needs and achievements.
b) Understands the importance of being a **member of a professional and intellectual community**, learning from its knowledge and standards, and contributing to their maintenance and advancement.
c) Demonstrates commitment to **lifelong learning** and professional development.
d) **Manages time** and processes effectively; prioritizes competing demands to achieve personal, career and organisational goals and objectives.
e) **Thinks critically** and applies an appropriate balance of logic and intellectual criteria to analysis, judgment, and decision-making.
f) **Presents a professional image** in all circumstances, including relations with clients, stakeholders, as well as with professional and technical colleagues across wide ranging disciplines.

Skills developed

The small group setting used in PBL encourages an inquisitive and detailed look at all issues, concepts and principles contained within the problem. The time spent outside of the group setting facilitates the development of skills such as literature retrieval, critical appraisal of available information and the seeking of opinions of peers and specialists. PBL encourages you to become more involved in, and responsible for, your own learning.

PBL will provide you with the opportunity to develop the following skills:

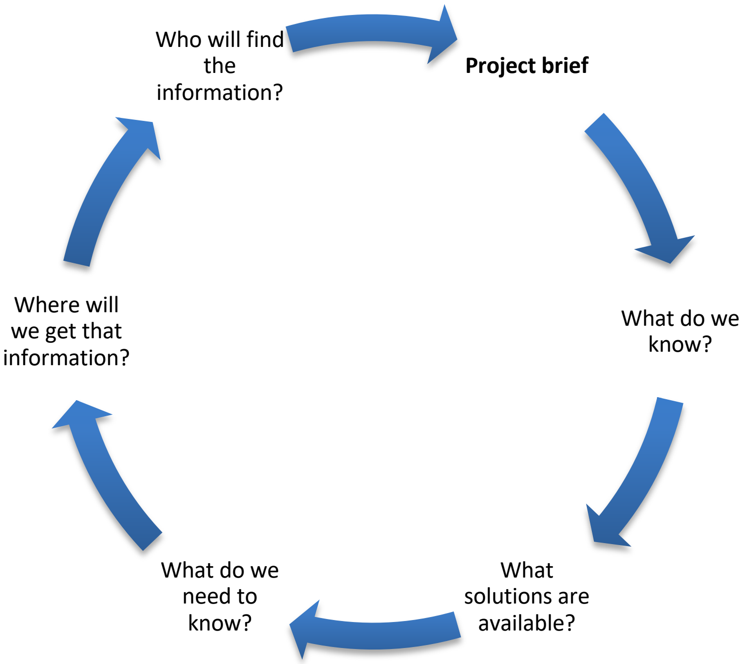
1. Problem solving skills
2. Thinking skills
3. Teamwork skills, including appreciating diversity of group members
4. Time management skills
5. Information retrieval and evaluation skills
6. Communication skills
7. Computing skills

Through your project work, you will also be learning to *be* an engineer. This requires the development of professional attitudes such as item (f) above:

f)	**Presents a professional image** in all circumstances, including relations with clients, stakeholders, as well as with professional and technical colleagues across wide ranging disciplines.

A Problem Solving Process

There are many ways of describing how to *do* project-based learning. In solving any problem, it's useful to have a bit of mental software that helps you get started and keeps you going towards the answer. This process has been adapted from (Landsberger 2007) and it provides the strategy for solving problems. It is a variant of the engineering method (Hadgraft 2007):



1. Explore the problem, e.g., read the project brief and discuss with group members.
2. List "What do we know?" – brainstorm among the group members – sticky notes and butchers paper are wonderful aids in this process
3. Try to write the problem statement in your own words – what are you asked to do?
4. List possible solutions.
5. List "What do we need to know about these possible solutions?" What are your knowledge (and data) gaps?
6. Where will we find that sort of information?
7. Who will do which parts of the additional research? (write an action plan)

   (At the next meeting) return to step 2 with new information. This may alter the problem statement and the range of possible solutions (3, 4). Otherwise, if the job is done, proceed to step 8.
8. Document your solution
9. Review your performance

What do we know?	What are possible solutions?	What do we need to know?	Where will we find this?	Who will find out?

This process always lets you get started, even with a problem you've never seen before. The worst-case scenario is that you'll have to go and do some research about the problem, either in the library or on the Internet.

The PBL method relies on a *divide and conquer* approach to gathering new information. Team members can each do some of this job and then at the next meeting *share* the new information with the group members.

It is important to prepare a *summary* of what you have learned. This might be a Word file, a mindmap, a diagram, or all of these things. This can be emailed to group members as well as uploaded to the group's website where all the project documents are kept. This is helpful in case people miss meetings and also so that they can refresh their memories about what you said three weeks ago. A wiki makes a good team website.

It is tempting to send these files around via email. However, emails get lost and they are very hard to search and find again. That's why a team *document repository* is so useful. When you go to work, you'll discover that's how engineering companies work now.

Use a free wiki site such as: http://pbworks.com to organise your group documents or Google Docs or Dropbox or Basecamp or … there are many options.

Have a look at FreeMind as a free mindmapping tool:
http://freemind.sourceforge.net/wiki/index.php/Main_Page

Engineering Projects and the Role of Design

The Lifecycle of an Engineering Asset

Engineers get involved at all stages of the life of an engineering asset – a bridge, tunnel, power station, mobile phone, etc. Some of these stages are:

Stage	Example
Strategic planning – What will we need in 5, 10 or 20 years' time?	How will we meet our city's water needs over this period?
Research & Development – What gaps in our understanding do we need to plug? How do we do this?	We need to research changing patterns of water consumption over the next 20 years.
Conceptual design – What solution do we need?	What is the next water supply option?
Detailed design – How should this solution be specified, ready to build?	If recycled water is the solution, how big does the plant need to be, what equipment is required, what will it cost, how will it be financed? Where should it be built?
Construction – How will we build the preferred design?	What project management and construction management is required? What equipment, people and other resources will be required?
Commissioning and Operation – What plans and training do we need to operate this plant? What regular maintenance is required? How will this fit around production schedules?	How will our new recycled water plant be operated and maintained? How will safety be embodied?
Decommissioning – Closing a plant or other asset. What else is required? Does it need to be demolished or recycled? In what way will the site be returned to its original state?	At some point, the recycled water plant will be inefficient or of limited capacity. It may need to be removed or refurbished, generating another project.

Of all these processes, design is the easiest to teach at university. The processes of conceptual design and detailed design are discussed in more detail below. In your university studies, you may also have opportunity to explore the engineering processes required in each of the other stages of the lifecycle of an engineered asset.

Competency being developed

Engineers Australia's competency statement for design is quite elaborate:

2.3 Application of systematic engineering synthesis and design processes.

a) Proficiently applies technical knowledge and open-ended problem solving skills as well as appropriate tools and resources to design components, elements, systems, plant, facilities and/or processes to satisfy user requirements.

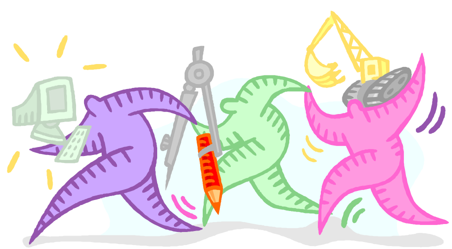
b) Addresses broad contextual constraints such as social, cultural, environmental, commercial, legal political and human factors, as well as health, safety and sustainability imperatives as an integral part of the design process.

c) Executes and leads a whole systems design cycle approach including tasks such as:
- determining client requirements and identifying the impact of relevant contextual factors, including business planning and costing targets.
- systematically addressing sustainability criteria.
- working within projected development, production and implementation constraints.
- eliciting, scoping and documenting the required outcomes of the design task and defining acceptance criteria.
- identifying assessing and managing technical, health and safety risks integral to the design process.
- writing engineering specifications, that fully satisfy the formal requirements.
- ensuring compliance with essential engineering standards and codes of practice.
- partitioning the design task into appropriate modular, functional elements; that can be separately addressed and subsequently integrated through defined interfaces.
- identifying and analysing possible design approaches and justifying an optimal approach.
- developing and completing the design using appropriate engineering principles, tools, and processes.
- integrating functional elements to form a coherent design solution.
- quantifying the materials, components, systems, equipment, facilities, engineering resources and operating arrangements needed for implementation of the solution.
- checking the design solution for each element and the integrated system against the engineering specifications.
- devising and documenting tests that will verify performance of the elements and the integrated realisation.
- prototyping/implementing the design solution and verifying performance against specification.
- documenting, commissioning, and reporting the design outcome.

d) Is aware of the accountabilities of the professional engineer in relation to the 'design authority' role.

The Design Process

Much engineering work requires the design of new artefacts (buildings, chemical processing plants, waste treatment facilities, electric vehicles, etc). Design typically moves through two major stages:



- **Conceptual design (or preliminary design)** is intended to recommend a suitable solution to a complex problem. It often requires broad estimates rather than detailed analysis. The basic question here is: *What solution is required?*
- **Detailed design** brings into play detailed analysis techniques for the specification of pieces of infrastructure and equipment. The basic question here is: *How will the solution be implemented?*

Both stages require the range of phases described below.

Phases

Projects typically pass through a series of phases as they move from client need to project implementation. These phases are shown in the diagram below. Each phase produces **documentation**, the lifeblood of engineering work.

Phase	Description	Documentation
Client Need	The **client need** begins the process, usually by providing a *client brief* to the consultant/engineer. The client brief may or may not provide a clear statement of the problem.	Client brief
Planning	At this stage, there needs to be some **planning** to decide how we will address this client need. This could be as simple as estimating the immediate workload impact and who might do the work. This planning results in a preliminary workplan or project plan.	Project plan
Problem definition	When the work begins, the immediate need is to properly **define the problem**. (Clients often report symptoms rather than problem definitions). From this phase comes a problem specification, which would often be discussed with the client so there is mutual understanding of the scope of work required.	Problem specification
Research	Around the problem definition, there is often the need for **research**, including data gathering. In fact, much of this may need to be done before the problem specification can be written. The research will produce a range of briefing papers on particular topics. The research phase will also identify potential solutions or actions for this problem.	Briefing papers
Selection criteria	An essential part of the problem definition is to decide on some **selection criteria**. All problems have multiple ways of being resolved. The selection criteria will be the measures against which we will evaluate all the possible solutions. Some of these will be quantitative (eg, cost, weight, height, loudness, salinity, etc) while others will be qualitative (eg, desirability, aesthetics, etc). They are usually developed in conjunction with stakeholders. The selection criteria will typically take a sustainability approach – social, environmental, economic and social criteria. Risk minimization and quality management will be other criteria.	Selection criteria (agreed with clients and stakeholders)
Alternative actions	A range of **alternative actions** needs to be identified. This will involve research as well as creative thinking, which is best done with your whole group. These alternatives would likely be discussed with the client.	Alternative solutions
Analysis	Once a set of alternatives has been generated, an **analysis** phase begins. This is the stage where your technical engineering skills come to the fore. Typically, there are many calculations to perform, calculating stress, energy needs, water quality, etc. Evaluation may also require	Computer analyses; summaries; design reports

Phase	Description	Documentation
	other forms of data gathering, eg, community surveys. This phase produces one or more design reports.	
Decision (choosing)	When all the data have been gathered, a **decision** must be made. Each alternative is evaluated against the original selection criteria and a recommendation made to the client. Much discussion (and disagreement) may ensue around this decision making process!	Recommendation report
Evaluation	An agreeable solution for the client does not end the process. Quality assurance processes within companies will require that the project process is **evaluated** for improvement possibilities. This is a reflective process that is aimed at improving company performance in a very competitive environment. This process may require talking with the client to make sure that they have received satisfactory service. This stage will result in some form of final project report.	Evaluation report

In the following diagram (Figure 1), these phases are presented as a Gantt chart, which is a common representation for engineering projects. It gives a quick visual representation of how the tasks (phases) are arranged within the project timeframe. It shows that you often have to revisit previous phases (eg, collect new information) before you can move forwards again.

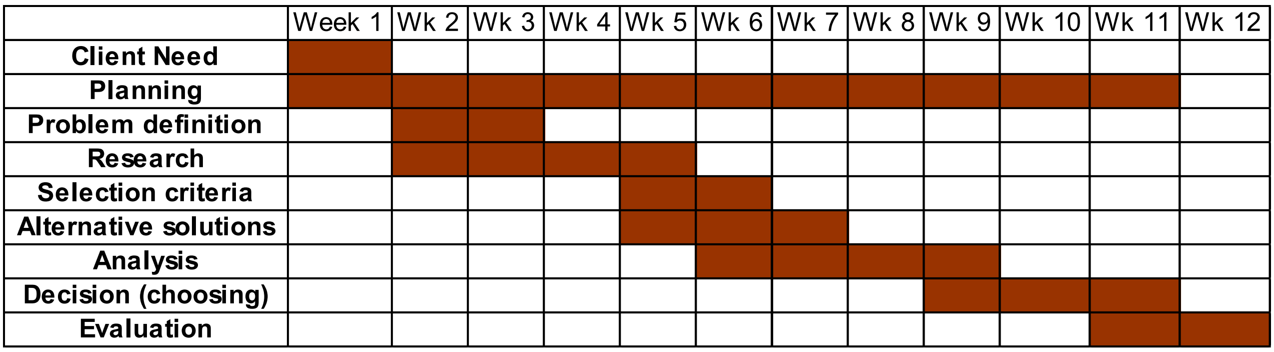


Figure 1 -Gantt chart of the process

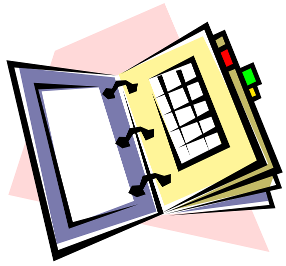
Once the project is complete, we are ready to begin a new project. Sometimes this means doing the detailed design once we're finished the conceptual design.

Detailed design

It is likely that at the end of the first problem solving round that the client wishes to move towards implementation. For example, if the recommendation is to build something, there will need to be a second round of design that produces a set of detailed drawings and specifications in readiness for tendering and construction.

Within this process, all of the phases mentioned above come into play at many different levels within the detailed design.

Documenting the process

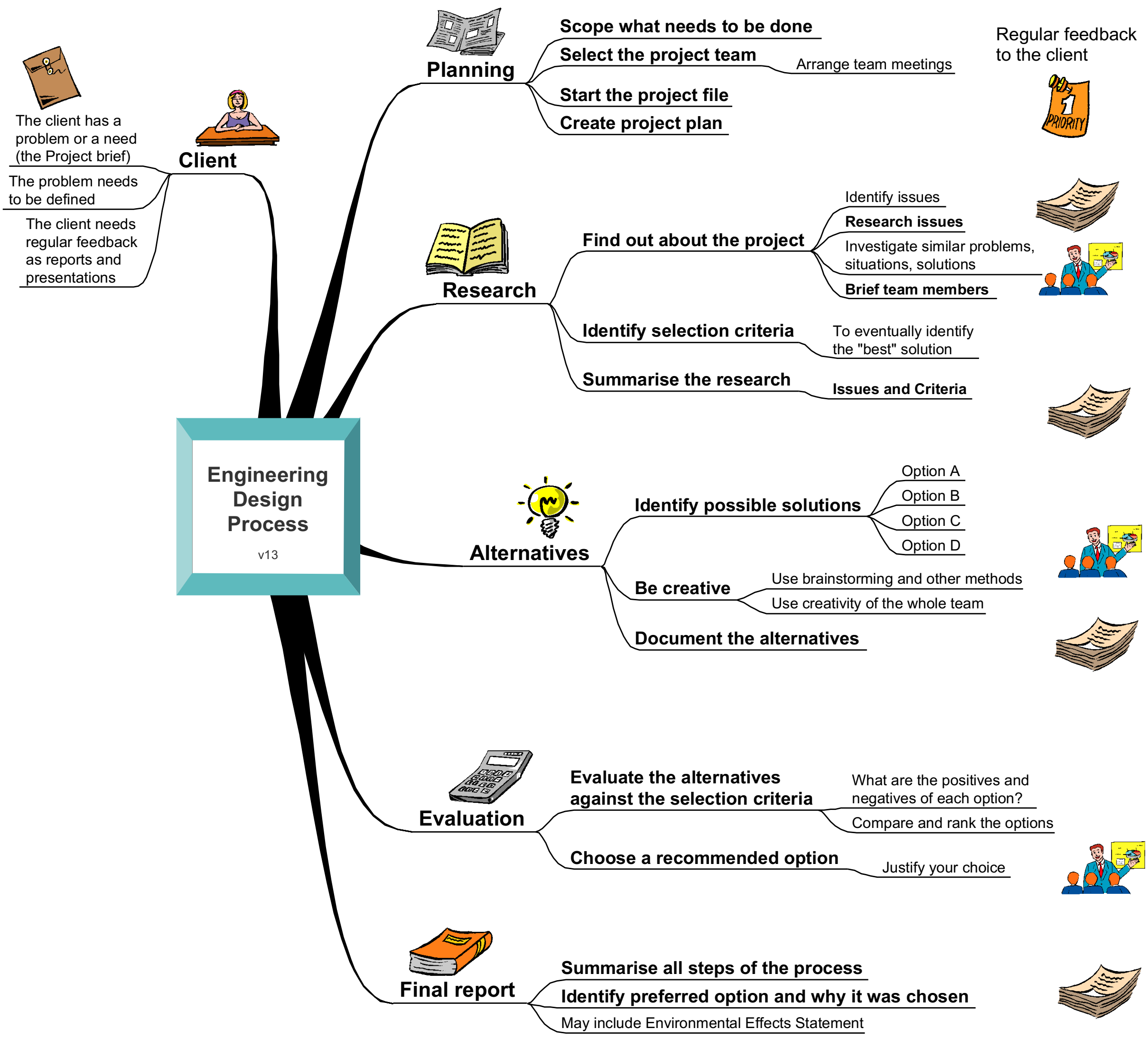


The discussion above clearly shows the range of documentation that must be produced within an engineering project. Any project team needs a way of keeping all of that documentation together, both on paper and electronically. There is more information in another chapter (p12) on keeping track of all this information using a **Design File**. We have also discussed the advantage of a group website or wiki for tracking all the documents you produce (p5). Email is also helpful, as are mobile phones and SMS.

In your design projects, we will ask you to submit some or all of these documents for assessment. The regular production of documentation helps us to project manage your design team (and all the other teams in the class). It is also an essential engineering skill, as described on p12.

Summary

Here is a summary of the design process as a mindmap:



More information

See Dowling, Hadgraft et al. (2016) and Dym and Little (2008) as well as many other introductory books on Engineering design.

Design file

When you generate the range of documentation described above, you need to keep track of it all and make it available to others, such as your boss and possibly the client. We call this a **design file**.

This will be standard practice when you work as an engineer. This is a significant shift in how you work. In the past, only finished, polished work (eg, assignments, essays) has been important. In engineering, neat, hand-written calculations, drawings, sketches and notes are also important project documents to be preserved for access by others. These are **NOT** word processed to make them look neat. They should be neat and well organised in the first place. Reports, of course, are summaries of all the work and they normally **are** word processed and made easy to read and understand.

Competency being developed

Engineers Australia (Engineers Australia 2017) describes this competency as:

3.4 Professional use and management of information.

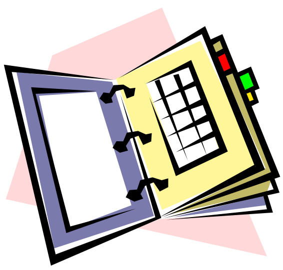
a) Is proficient in **locating and utilising information** - including accessing, systematically searching, analysing, evaluating, and referencing relevant published works and data; is proficient in the use of indexes, bibliographic databases, and other search facilities.
b) Critically **assesses** the accuracy, reliability, and authenticity of information.
c) Is aware of common **document** identification, tracking and control procedures.

Contents

Your design file will include **three basic types of information**:

1. **Record of your own work** – notes, sketches, library searches, meeting notes, agendas, action plans. You should be able to show at least one example of each of these things. This is important if you are accused of doing no work in your group. This should be evidence to the contrary. There are pro forma for some of these things in the Appendix of this Handbook.
2. **Collection of all relevant documentation** – handouts from class, web pages printed, photocopies, plans, etc. Include copies of your own submissions.
3. **Personal reflections on the process** – this is where you think out loud about what you're learning. In some classes, you'll be given a reflection question each week. So, as a minimum, this would be the collection of those answers. These writings can also feed into your evaluation report at the end of the semester. There is more detail about writing reflectively in a later chapter (p. 13).

Form of the Design File



Your design file should be a **ring binder**, or similar, with **section separators**. It must have a **Table of Contents** at the start to describe its major sections.

You should organise the design file into major sections based on the stages of the project (as in p.9) or you may find another way of grouping together the work.

It should be **auditable at any class** (or perhaps according to some schedule, as agreed with your tutor).

Record of your own work

Information to be included includes:

- Agendas and Notes from meetings
- Action plans – what needs to be done and who will do it
- Library and internet searches – search terms, results, web page addresses, references for books, journals, etc
- Phone conversations
- Significant email messages, eg, containing important data
- Results of class discussions
- Brainstorming activities
- Sketches
- Mindmaps
- Gantt charts (see later)
- Summaries

> Submission of the logbook will be a required component of assessment in many of your projects.

And so on. Pro forma for some of these standard entries are given at the back of this handbook (p.43).

A pro forma for computations (as used by most engineering organisations) is given at p.46.

Sharing with group members

Much of your research you'll want to share with group members. Useful computer tools for this are Dropbox and Google Docs:

- Dropbox installs transparently on your computer or mobile device and it allows you to share documents with each other with minimal effort. Once I put a file in a shared folder, my collaborators can often see it in seconds if they are online. Dropbox works on mobile devices as well as PCs and Macs.
- Google Docs is a more closely controlled environment that allows you to edit documents collaboratively. It also controls access to the documents so that two people can't edit the same document at the same time.
- There are many other cloud-based file sharing programs.

Collaborative group discussion

As well as sharing documents, it is also useful to have a discussion space for posting useful information, web links, conversation, etc. There are many tools for this purpose, including Facebook, Yammer, your LMS's Discussion Boards, etc.

Project Management

Definition

Modern Project Management was first used to manage the US space program. After its initial success, it expanded rapidly through the government, the military and the corporate world. Project management is no small task. It is defined as having a definite beginning and end and it is not a continuous process. Project management uses various measurement tools to accomplish and track project tasks (WPM, Gantt, PERT charts). These are described later. Projects frequently need resources on an add-on basis as opposed to organizations that have full-time positions.

There are three main points that are most important to a successful project:

1. A Project must meet customer requirements (**quality**)
2. A Project must be under budget (**cost**)
3. A Project must be on time (**time**)

Quality – Defined as the degree to which the facilities or deliverable products meet the specific requirements**.** Did the customer get what the customer asked for?

Cost – This requirement refers to the amount of money – the capital cost – the client wishes to spend to complete the project**.** Cost can also be referred to as management of one's own time spent on the project

Time – Requirement refers to the calendar date by which customers want the project finished so that it can be used for the customer's purposes**.** It also implies intermediate dates for stages of the work to be completed along the way

Project Manager – Roles and Responsibilities

A project manager is expected to:

- Direct and supervise the project from beginning to end
- Define the project, reduce the project to a set of manageable tasks, obtain appropriate and necessary resources, and build a team or teams to perform the project work
- Set the final goal for the project and motivate workers to complete the project on time
- Have technical skills (financial planning, contract management, managing creative thinking and problem solving techniques, etc)
- Learn to adapt to change as no project ever goes 100% as planned

Why Projects Fail

Projects fail in many different ways but are successful in only one – when everything goes right! Some examples of why projects fail are:

- The project lacks higher management support and resources
- Tasks and goals are vaguely defined
- Planning and pre-project preparation are inadequate
- Management methods are inappropriate or misused
- Communication is insufficient
- Technical and managerial skills are missing

- The project manager is lacking in skills and experience

Project Management Tools

Projects are successful if they are completed on time, within budget, and to performance requirements. A number of techniques, methodologies, and tools are available in order to accomplish this. Such techniques provide the tools for managing different components involved in a project for example planning and scheduling and monitoring progress

Work Breakdown Structure (WBS)

This tool is related to planning and scheduling a project. Basically, it is a functional decomposition of the tasks of the project. The total work of the project is broken down into major subtasks. It starts with the end objective required and successively subdivides it into manageable components in terms of size and complexity, which may include program, project, system, subsystem, components, tasks, subtasks, and work elements. While a WBS is useful for defining the work required for complex projects, it does not show the timing of activities.

Gantt Charts

These were developed by Harry Gantt in 1916. Charts give a timeline for each activity. They are used for planning, scheduling and then recording progress against these schedules. Two basic types of Gantt Charts exist. These are *Load Charts* and *Project Planning Charts*.

Load Charts – Useful for manufacturing projects during peak or heavy load periods. The format of the Gantt Load Chart is very similar to the Gantt Project Planning Chart.

Project Planning Chart – Addresses the time of individual work elements giving a time line for each activity of a project**.** These charts are easy to understand and show when each activity starts and finishes. However, the chart cannot determine when each activity may start or if we can start a particular activity before finishing the immediate predecessor activity**.** Need somehow know the precedence relationships between activities (PERT / CPM charts).

Here is a simple Gantt chart created in Excel:

Week	1	2	3	4	5	6	7a	7b
beginning	27th Feb	6th March	13th March (Public holiday)	20th March	27th March	3rd April	10th April (Monday)	17th April (Friday)
Task								
1	Poster							
2		Briefing paper						
3				Feasibility paper				
4						Generate alternatives		

PERT (Program Evaluation and Review Techniques) / CPM (Critical Path Method)

Both methods show precedence relationships explicitly. They are used to portray graphically the interrelationships of the elements of a project and to show the order in which the activities must be performed.

What does this mean for me/us?

As you begin your project work, you are beginning to learn project management. We will ask you to prepare (and revise regularly) a Gantt chart to show the tasks required in your project. You should estimate the resources required for each activity (eg, hours of work). How will you get the task done by the due date?

We will ask you to have group meetings and keep proper records of matters discussed and action items. At your next meeting you will check that actions have been completed.

We will ask you to work in groups in order to gain experience with working with difficult people. (We are all difficult at times).

Other aspects of project management will become clear as we proceed through subsequent projects.

Reflections – managing the process[1]

Since most students have never been exposed to reflecting on their own work, we have covered this in some detail to get you started. These reflections will be interspersed throughout your design file.

Why write reflections?

Reflecting on your project and the learning process **helps you to learn**. The more you think about the concepts and issues in your subject area or projects and connect them to what you know and see around you, the more you remember and learn. It also helps you to think about what next you have to do in your project work.

When you go to work, you'll find your fellow engineers using the same process.

Competency being developed

Engineers Australia describes this as:

PE3.6 Capacity for lifelong learning and professional development

a. Recognise limits to own knowledge and seek advice, or undertake research, to supplement it

b. Take charge of own learning and development; understand the need to **critically review and reflect on capability**, invite peer review, benchmark against appropriate standards, determine areas for development and undertake appropriate learning programs

c. Commit to the importance of being part of a professional and intellectual community: learning from its knowledge and standards, and contributing to their maintenance and advancement

d. Improve non-engineering knowledge and skills to assist in achieving engineering outcomes

Action Learning (Learning in Action)

Action Learning [??] is a specific methodology that acknowledges that learning happens when we are involved in activity. A simple summary of this approach is the following cycle:

Plan → Act → Observe → Reflect → Plan → Act → Observe → Reflect → Plan …

The first two steps are obvious. As a trainee engineer, you **plan** the design of a bridge or printed circuit board. You **act** by working with other people, to complete the design. You **observe** what is happening in your group and realise that there are real differences of opinion about how to complete the design. (You add these observations to your logbook). You **reflect** on these differences and resolve to try a new approach (your new **plan**). You add these reflections and new plan to your logbook.

At your next meeting, you **act** by presenting to the group your new idea. You **observe** the discussion that follows, and so on. Later you **reflect** on whether your new plan was successful and what now needs to be done.

So, you develop a strategy of **continuous improvement** in your work, through careful observation and reflection, documented in your logbook.

What do I observe (and write about)?

This process of plan-act-observe-reflect is useful in everything you do – both technical subjects and projects. Some really useful questions are:

- What's going well at the moment? (it's always good to start with positive things)
- What's not going well?

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[1] The RMIT Learning Skills Unit shaped this section (https://emedia.rmit.edu.au/learninglab/content/study-skills).

- What could we be doing to improve things?
- How will we do that? (process)

The following prompting questions give you other ideas for reflection questions:

Course Content

New information gained. Things that struck you as interesting

e.g. I really liked Tony's bridge design. I hadn't thought of merging the two designs.

Questions raised (they may be still unanswered)

e.g. Why is this model stronger than the other one? (explains)

Application to your own situation or something you've noticed outside the course.

e.g. There is one of those bridges in my city in Korea. I'd never really thought about the design before but now I see…

Process

How the information was presented

e.g. I was inspired by the guest speaker who talked about water systems. He really…

How you gained your insights

e.g. I seem to learn best when there are plenty of examples.

What else you could do

e.g. I need to work on my report-writing skills, particularly the introduction.

What works best

e.g. The group functions best if we make clear tasks and deadlines. When people are late it… (explore feelings and dynamics)

Analysis and insights

How the information fits together

e.g. I can now see how that formula can be applied (then give example)

The inter-relationship between different aspects of the content

e.g. That design could also be used in… (describe another situation).

Application to other situations/cultures

e.g. Those environmental concerns also apply to (describe another relevant context)

Evaluation of the ideas/concepts raised

e.g. I agree with the models of energy efficiency, because…(explain why)

What kind of style can I use?

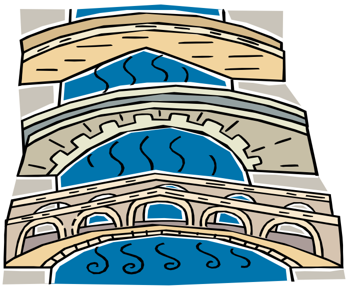
Logbooks are not formal academic pieces of writing. The style is pretty flexible. You might use:

- informal language including the first person (I) voice and casual expressions
- abbreviations
- bullet points
- some diagrams and charts
- brainstorms or mindmaps
- rough sketches
- as well as more connected writing.

How could I set out the logbook?

Here are some samples adapted from first year civil engineering logbooks.

Sample logbook extract 1

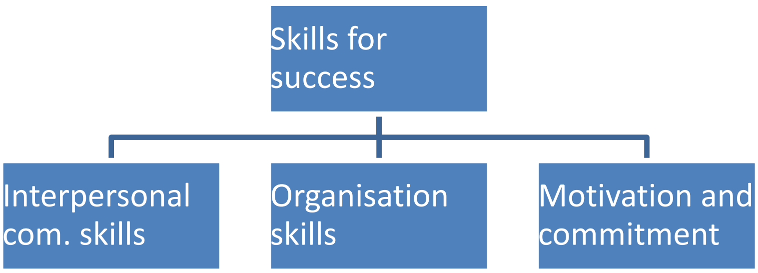
Date: X/X/XX	What's happening in the writing
Today I thought was one of the most challenging statics tutorials we've had – not with the difficulty but with collaboration in the group. We had a hot debate about the structure and two members confronted each other in a bid to have their structures acknowledged. The power struggle wasted a good half an hour. I tried to get them to come back to the guidelines and requirements but we had run out of time and no decision was made. I now realise a couple of things:	Tells about group incident Gives insight into group dynamics
Managing the dynamics in the group is really important – you can waste a lot of time if you are not focussed on achieving an outcome. We need to set some clearer expectations in the group.	Reflects on group process and possible solutions
Since then I've been thinking about a particular bridge – it's a simple design but a bit different and I hope the team will like it and also have some fresh ideas for improving it or other ideas themselves.	Reflects on a number of areas.
	Includes sketch
Maths has been getting pretty difficult lately. I've got more work to do in this area although with a part-time job I'm starting to feel like I'm running out of time in the week to fit things in.	Identifies some weaknesses

Sample Journal extract 2

<table>
<tr>
<td>Things are going pretty well so far. Chemistry and Physics I did last year so I'm going OK there. I didn't do specialist maths though so maths is going to take a bit more work (and time). I can see time-management is going to be a big issue at uni. When I get my lap top I'll be able to use the time on the train a bit more effectively, just going over notes and writing up my log book etc.</td>
<td>What's happening in the writing

Reflects on a number of areas.

Identifies some weaknesses and a possible solution</td>
</tr>
<tr>
<td>Our first project in CIVE was to present a poster on Civil engineering. It was good to think a bit more broadly about engineering and to get to meet a few people. I guess I imagined I was going to be a structural engineer but I can see there are a lot of jobs that engineers do. It will be good to go on the fieldtrip and see this a bit more first-hand though it seems a long way to go when there's a lot of things being built in the city. It must be a special project or have particular things they want to show us.</td>
<td>Could have given more detail on the other jobs engineers do.</td>
</tr>
<tr>
<td>I have been thinking about the qualities needed for success at uni (and in life probably) that we talked about in class.



</td>
<td>Brainstorm in diagrammatic form</td>
</tr>
</table>

Effective Groupwork[2]

Objective

This chapter is designed to help your group work more effectively. It is assumed that you have already had experience of working in groups.

The key to an effective group is to work on the **relationships** between group members. This is not a natural activity for many people, particularly for males!

Competency being developed

Engineers Australia describes this competency as:

PE3.5 Ability to function effectively as an individual and in multidisciplinary and multicultural teams, as a team leader or manager as well as an effective team member

a. Manage own time and processes effectively, prioritising competing demands to achieve personal and team goals and objectives

b. Earn trust and confidence of colleagues through competent and timely completion of tasks

c. Communicate frequently and effectively with other team members

d. Recognise the value of diversity, develop effective interpersonal and intercultural skills, and build network relationships that value and sustain a team ethic

e. Mentor others, and accept mentoring from others, in technical and team issues

f. Demonstrate capacity for initiative and leadership while respecting others' agreed roles

What is an effective group?

Effective groups are a delight. Work is done with seemingly little effort, because everyone is keen to do his or her share. Ideas are generated quickly and effortlessly, and no one seems too attached to their ideas. Group achievement is more important than individual achievement.

How can you move your group and yourself to this state of performance? It requires a conscious application of some simple principles and an awareness of oneself and how one behaves with others.

Getting Started

Introductions

Be open and honest with each other.

Introduce yourselves by saying what you bring to the group. This may be an interest or experience in a particular aspect of the problem for which you've assembled. Describe your interest and goals. Take a minute or two each. A mindmap is provided in the Appendix as prompts for this conversation.

Be interested in what others have to say. Note down people's names and interests as the discussion progresses.

There are two purposes for this stage:

1. one is to get to know each other, because it's easier to work with people we know,
2. and the other purpose is to look for *assets* in the group to make it easier to complete the task.

[2] (with contributions from Dr Will Rifkin, formerly UNSW, currently University of Newcastle)

Get to know each other better

Take a personality test on the web (eg, http://www.personalitytype.com/quiz.asp). Discuss your preferences with each other. What roles in groups do you prefer? What roles will others choose? Are there any missing?

Basic roles

A group needs a *chairperson*, so if you haven't already done so, someone needs to take on that role, even if you later pass the role around the group. This person will make sure that tasks are completed on time. This usually involves chairing meetings.

Arrange to have a meal together and get to know each other on a more personal basis.

Appoint a *scribe* from the group who will record discussion and action required as a permanent record for everyone to keep.

Use your different abilities

Recognise different abilities that each team member has. This includes personality type, but is not limited to it. By getting to know each other better, and being open with each other, talents will emerge in the group. Make the most of them.

Look for talents in your team.

Write a team contract and be honest about it

Delineate responsibilities common to all team members; also delineate different tasks undertaken by different people.

Address some contingencies – illness, slackers, accidents, those just not excited by the class or project; be honest about how much work you are willing to put in and what mark you would be satisfied with. You can propose different marks for different team members, the hyper-dedicated person getting points from each other team member in return for extra work.

One way of preparing a **Group contract** is using the 5 P's:

1. The **Purpose** of the group – *why* your group exists, e.g., learn about the design of simple structures, design a chemical plant
2. Your **Policies** for effective groupwork – *what* are your expectations, e.g., everyone attends all group meetings, or provides a valid apology (including a chocolate bar)
3. Your **Procedures** – *how* you will go about it, e.g., provide each other with weekly feedback (both positive and negative); how you will handle *non-performing group members*.
4. Your **Performance indicators**, e.g., meeting attendance, deadlines met, conflicts resolved, group social activities, feedback given, marks achieved.
5. Your **improvement Plans**, e.g., how you have coped with setbacks.

Although steps 1-3 may be written only once, steps 4 and 5 should be visited regularly (weekly, fortnightly, monthly) depending on the duration of the project.

A mindmap is provided to assist you in getting through your contract negotiation. Negotiating a contract will prove critical in your professional life, and it can be a lifesaver in team projects at university. During negotiation, you begin to learn about the people you are working with by observing how they negotiate. How candid do they seem? What seems to motivate them? Do they try to get their own way, or do they try to accommodate, and why?

Assess each other and give feedback

A simple marking scheme is:

- 0 for average, expected work
- +2 for good work
- +4 for excellent work
- -6 for non-performance (doesn't complete tasks, doesn't attend meetings).

Assess yourself and each of your group members each week. Be honest! Very few groups have everyone performing at the excellent level. At the end of the semester, your lecturer may ask you to give a summary score for each member of the team, including yourself.

Discuss these scores from time to time. We all need feedback to know whether we're performing up to others' expectations.

Learn from each other

Enable someone weak in one ability, such as presentation skills, to practise that, even though someone else might be better at it. Help this group member to do the best job possible by rehearsing beforehand. University is a good place to practise – far more forgiving then the workplace. Document how the group has permitted this individual to improve their abilities.

Build a learning team.

Expect conflict

Aim for debate about ideas and strategies rather than personality conflicts. Try not to get too attached to your ideas or your way of doing things.

When people get combative, just say *stop! I thought we were all on the same team.* Discuss why you might be getting on each other's nerves. This may be due to personality type differences.

Expect differences of opinion.

Divide and conquer

Some work and decision making needs to be done by individuals or by sub-groups; trying to gather everyone together to work jointly all the time can be futile and unproductive. Establish effective ways of communicating – employ e-mail or a team web site (and agree to check it daily), record best times to phone each person or use messaging.

Use action plans

At the end of each meeting, fill in an action plan. There's a template in the Appendix for this:

- What is to be done?
- By whom?
- By when?
- Also: Why? How? Where?

At the beginning of the next meeting, check that the tasks are complete or keep them on the action plan until they are. If they are no longer required. Mark them with an X (deleted). If you keep this action plan in Word or Excel, you will have a continual record of work done by the team. This is useful to demonstrate what you have done, as part of your personal portfolio or design file.

Find out why tasks haven't been completed. Sometimes tasks are not completed because the delegated person doesn't know how to start it. Some help with *how to do the task* will be required.

Make sure that a copy of all action items goes in your logbook each week.

Use *good practice* feedback

A good strategy is to remember to give *positive feedback*. Although we often do this with children, most adults forget that we also need to give each other praise:

> *Hey, I really liked what you did with the drawings for our multistorey carpark project!*
> *I thought you'd put a lot of effort in the detail of the drawings.*

Always start with positive feedback. You might then want to ask the person to do some additional work:

> *I think the drawings would be improved by the addition of another 3D view. What do you think?*
> *The lecturer is probably expecting to see a view from the entryway.*

Conflict resolution

When something concerns you about another group member's behaviour, try using "I" statements as follows:

> *"When you come late to meetings, I feel angry and frustrated*
> *In future, I would like you to arrive on time like the rest of us; what do you think?"*

It sounds awkward, but it works! What is important is that you *acknowledge your own feelings* in the process. The other person may be totally unaware how their actions are affecting you.

If you can master giving feedback this way, many relationships in your life will improve – not just your groups/teams at university.

Logbook

Keep a record of all your work on the project. You will need an exercise book (or maybe you'll do this on your computer) where you will keep notes of meetings, emails, phone calls, library searches, and so on.

It also serves as a useful lifeline if you need to justify the work you have spent on a project. It may also be a formal assessment requirement, as part of your portfolio.

Reflection

Each week you should write some reflection on your progress in doing the project:

- What have I learned about the project (and engineering in general)?
- What new learning do I need to do?
- What am I finding really challenging/difficult? Why?
- What am I finding fun? (usually things you're already good at)
- What have I discovered about myself? (things you're good at, or things you need to improve)
- What concepts have you learned that will help you to be a more effective professional?

Use these reflections to look for new learning opportunities. Studying at university is about learning. Getting the project completed is a means to that end; it's not an end in itself. If you're not learning anything in your project work, you're not working hard enough!

Reflection is considered in another chapter of this handbook.

Conclusion

It is very important that you follow these guidelines in each of your team projects. Many groups never get to know each other well enough to form a productive team. In particular, they never learn to deal with conflict in a constructive way. If you don't get to know each other well, you will not be able to trust each other enough to move to a higher level of productivity.

More information

Teamwork is discussed in more detail at:

- http://project-handbook.pbwiki.com

Research in the Library

Original chapter by Heather Ross, School Liaison Librarian, RMIT Library

Subject Guides

Your own library will have subject guides to help you get started. For example, at UTS, they are here: http://www.lib.uts.edu.au/guides

Searching the Literature

Identify types of resources to be searched

Do you need background information?	Consult textbooks, encyclopaedias, dictionaries	**General search engines** for definitions, general readings. **Library resources** – check subject guide for suggested titles or search the Library catalogue. Some will be online, others in print.
Do you need recent, focussed information on narrow aspects of the topic?	Search for journal articles, conference papers.	**Library databases** – consult subject guide for the most relevant titles. Some articles and papers will be available in full-text. **Google Scholar** for additional "scholarly resources", some available in full-text. **General search engines** for a variety of free, mainly full-text resources.
Do you need specialised materials?	Design data	**Books** (printed) – check subject guide for suggested titles.
	Cost data	**Books** (printed) – check subject guide for suggested titles, eg, Rawlinson's construction costs
	Standards	***Australian Standards Online*** database via online subject guide or the Library's **Search it** gateway, or ***ASTM Standards*** in print – see subject guide.
	Patents	Free **Internet databases** – check subject guide for suggested URLs.
	Technical reports	Free **Internet databases** – check subject guide for suggested URLS – or search a known site e.g. Austroads at http://www.austroads.com.au/

Define your topic

(Consult your supervisor; do background reading to better understand)

Develop a strategy for searching databases and Internet search engines

1. Identify the key aspects of your research question or topic.
2. Compile a list of keywords and phrases for each aspect of the topic, identifying alternative or synonymous terms, variant spellings and abbreviations.

ALTERNATIVE TERMS	PLURALS / ALTERNATIVE ENDINGS

greywater, domestic wastewater, household water	stadium, stadiums, stadia
ALTERNATIVE SPELLING	**ACRONYMS / ABBREVIATIONS**
greywater, graywater, grey water, gray water	FRC, fibre reinforced concrete

3. Define the relationships between your keywords with the Boolean operators **AND**, **OR** and **NOT**. Library databases and most web search engines use Boolean operators.

OR finds records that contain any of the terms e.g. greywater **OR** domestic wastewater.
It broadens your search, increasing the number of references retrieved.
AND finds records that contain both terms e.g. greywater **AND** biofiltration.
It narrows your search, reducing the number of references retrieved.
NOT finds records with the first term, but not the second. E.g. greywater, **NOT** blackwater.
Use with care; it is easy to exclude relevant references where aspects of both words are considered or compared.

4. Be prepared to try different combinations of terms.
5. After your first search of each database or search engine, scan the resulting references for additional or alternative terms to incorporate in your search strategy.

Search library databases and Internet search engines

Library databases

- Almost all can be used from off-campus.
- Often more scholarly than Internet resources, better quality controlled through peer review process, indexing is more consistent.
- Tiny compared to Internet search engines, require more structured searching.
- Many databases are not full-text, although it may be possible to link to the full-text provided as part of another library database via the Library's **Find it** service.

Google Scholar www.scholar.google.com

- Coverage – strong bias towards life sciences/medical sciences.
- Some free full-text
- To access full-text already paid for by your university Library, you need to be authenticated, so access Google Scholar via the Library's interface

Google and other general search engines

- Use advanced search features for flexibility.
- To reduce large results, limit by date, language or part of the document searched.
- Users need to evaluate all references.
- Shortcomings – they do not usually index commercial databases and some databases of free specialised materials.

Presentations

Most of you will have some experience of giving presentations, either from school or from earlier years of the course. This page is designed to remind you of some of the things you **should** do, and some of the things you should **not** do.

You should

Organise

Plan what you have to say. What are your main points? Avoid excessive detail.

- Use **mindmaps** or outlining in your word processor.
- Plan the **logical development** of your ideas.

Use the 3 stage process:

- Start with an *overview* of your main points.
- Then develop each of your main points in some more detail.
- Finally, *summarise* each of your main points.

Present confidently

- Speak in a **clear, loud voice**. Project your voice to the back row of seating.
- **Maintain eye contact** with all of the audience. This takes a conscious effort. Don't watch the screen where your slides are projected.
- Be **confident** and **enthusiastic**. This takes practice!
- **Stand tall** and relaxed. **Smile**!
- Use **effective visual aids** that everyone can see.

You should NOT

- Be disorganised. Preparation and organisation are essential.
- Read your talk. This is very boring for the listeners and they will quickly lose interest.
- Speak with cue cards. Use visual aids instead.
- Speak without visual aids. Have at least one overhead that summarises your main points – **no more than one slide per minute** of presentation.
- Hold up an A4 sheet at the front of the class and expect everyone to be able to see it. Make it into an overhead.
- Use small type on your overheads. 24 pt is a minimum. Learn to use PowerPoint.

The most common mistakes

- **No Introduction**. Tell us where you're going. Use a summary overhead to explain the main parts. Introduce the other speakers and what they will be covering. (This could be a simple table on one slide).
- **No Conclusions**. BIG mistake! Copy your summary slide to the end. Tell us again the main things that you've covered. Remind us of the key elements/innovations/strong points of your design. What do you want us to remember about your work? Remember that we will be as attentive as you are in lectures. ;-) Invite questions that address any of your key issues.
- **Too much detail**. We want an overview of what you've done. Where you need to talk about detail, do it sparingly.
- **Text that is too small** on slides. Use no more than 30 words per slide. Text should be 24 pt and larger. Use PowerPoint's default ability to produce well laid out slides.
- **Tables of data** fall in the same category. Make them into charts. Keep them simple. Enlarge text when required. (Excel text on charts is usually too small without modification).

- **Reading your presentation**. If you need to write a script, summarise it onto your overheads then throw your script away. If you forget to say something, only you will know. The only notes you should need are your overheads. Forget about palm cards.
- **Looking at the screen**. Watch the monitor in front of you to see your slides. Maintain eye contact with the whole audience, not just the lecturers.

Finally, **dress** for the occasion. Sloppy, casual street clothes do not belong at a professional presentation. Dress as if you're at a job interview.

Quick Tips for an Effective Poster

Posters are another way of communicating your information. They are best used as an aid to a discussion and should only represent the essence of your topic. Remember – less is more. Most of you will have prepared some posters before. This page is designed to remind you of some of the things you **should** do, and some of the things you should **not** do.

You should – Plan

Before you rush to your computer and start designing your poster, there are a couple of things you need to do first. Planning your poster is extremely important.

Start by writing down everything you would like to have on your poster, keeping in mind your target audience.

Draw your poster on a piece of paper, adding all the different sections and headings you would like to cover in your poster as well as the text. Let someone proofread for grammatical and spelling mistakes.

Use Visuals

Graphics, photographs, diagrams, etc., are very important components of your poster. They will add interesting visuals to the poster, helping you to get your message across. Enlarge and crop your visuals, if necessary, by zooming into the relevant part of the picture/visual. Make sure that your visuals are clear and of good quality.

Use Colour wisely

Colour plays a very important role in posters. Choose colours that complement each other. Certain colours, like certain yellows, etc., are difficult to see and read. Text and background colours should complement each other. Make sure your foreground colour (text) is clear and soft on the eyes when combined with the background colour.

Use different text size & font type

Text size & font type are a very important aspects when designing a poster. They will determine whether your audience will be able to read your poster with ease. If not, all your hard work was for nothing. Choose a font type that is easy to read. Use the following text sizes:

Main title	100 points	At least 4 cm high.
Subheadings	48 points	Between 1.5 – 2 cm high.
Body text	24 points	Between 0.5 – 1 cm high

You should NOT

- Add unnecessary or irrelevant information to your poster.
- Don't use too much colour – it will look busy and cluttered
- Don't add too many visuals, the poster will just look "busy"
- Use small type. 24 pt is a minimum.
- Dress in sloppy, casual street clothes – these do not belong at a professional poster presentation

Presentation assessment

Presenter:...

Assessor: .... **Date:**...................................

Assess each of the following criteria for the speaker. Use these to form an overall score for the speaker. (G=Good, S=Satisfactory, N=Not satisfactory).

Content

Well planned and structured (clear beginning, middle, conclusion) Good breadth versus depth balance (not too detailed, not superficial) Showed deep understanding of the material (eg, answers to questions)	E G S N	Poorly planned and structured (eg, no conclusion, just stopped) Poor breadth versus depth balance (too detailed or too superficial) Understanding of the material seemed doubtful (unable to answer many questions)

Visual aids

Easily readable (large font, simple diagrams) Visuals contributed well to the understanding of the seminar Attractive, simple use of font styles. Clear, large, easy to read diagrams, photos and charts. Well scanned, clear line work. Easily readable from 3 m	E G S N	Too much text or text too small. Too many text styles. Small, messy diagrams Barely readable from most seats Visuals contributed little to the effectiveness of the seminar

Presentation

Clearly audible voice, well-modulated, interesting voice at a good speed. Good eye contact with the audience. Confident posture, effective use of gestures and humour	E G S N	Inaudible voice (too soft, mumbled, …), dull and lifeless voice, spoken too quickly or too slowly. No or little eye contact. Insecure posture, little use of gestures or humour
Overall score:	E G S N	

Well done	Suggestions for improvement

Generating Alternatives and Creativity

Any engineering project will have a range of possible solutions. Your challenge is to list as many as you can so that you can present the client with some useful choices.

Brainstorming

There are a range of techniques that will help you be more creative. One easy method is brainstorming. The idea is to generate as many ideas as possible in an agreed amount of time. You might aim for 20 ideas in 10 minutes.

One simple way is to spend just a few (silent) minutes where each person writes their own ideas on sticky notes, one idea per note. Then, at the end of those few minutes, share them on the table and cluster them into similar ideas.

Then begin to elaborate them. Sometimes you'll see an idea and add another way … that makes me think about this …

As the ideas flow, even better, new ideas will emerge. Write down (in your logbook) all the ideas as they emerge.

Some crazy ones will emerge too, but that's ok. They can be eliminated later. The crazy ideas often provide the impetus for new, good ideas.

What goes wrong with brainstorming is that group members want to talk about, or *elaborate,* their ideas. This takes a lot of time. The other thing you will be tempted to do is to *criticise* other people's ideas. "That will never work, because …". Resist this too. So, **no elaborating and no evaluating** during brainstorming. Just name the idea and move on.

At the end of 10 minutes, or the agreed amount of time, you can begin to **evaluate** the list. With a bit of luck, your group has produced a whole range of good ideas. Some new ideas might even emerge at this stage, sometimes by combining ideas on your existing list.

Sustainable creativity

One useful approach for generating alternative solutions is to use the sustainability criteria (explained in more detail in the next section). These require any solution to satisfy economic, environmental and social constraints. Of course, any solution must also satisfy technical requirements (strength, serviceability, etc).

For example, say we were looking at the future water supply for a major city, how could we use these four factors to help us generate alternative solutions?

Criterion	Possibly solutions
Technical	• Build another dam • Build a desalination plant • Install water tanks at homes to capture stormwater • Recycle wastewater for industry use • Install greywater recycling at home level
Economic	• Make water more expensive so that people use less
Environmental	• Encourage residents to plant gardens that require less watering (often half our water use is watering our gardens)
Social	• Create education programs to conserve water • Make laws to prohibit behaviour such as cleaning driveways using water

No doubt you can think of others to add to the list.

More information

There are many books and websites devoted to creativity. Look for Edward de Bono's work on Lateral Thinking and also look for information about TRIZ. See http://www.edisons21.com

Exercise

Write down 20 (or more) ways to improve use of public transport in your city.

Selection criteria, Sustainability and Decision making

In choosing the **best** alternative for an engineering project, you need to have some clear **criteria**.

Sustainability

One obvious criterion is **technical adequacy**. An engineering system needs to be “strong” enough to satisfy the loads placed upon it. For a structure, this will include material strength and serviceability, as well as resistance to fire, fatigue, corrosion, and so on. For a pipeline, it means adequate flow capacity, pressure resistance, corrosion resistance, etc. These criteria we will call the **engineering** requirements.

The next most obvious criterion is **economic adequacy**. The system needs to be affordable by the client. It is reasonable to expect that the engineer has made some effort to design a system at minimum cost (subject to other constraints).

The third criterion is **environmental impact**. The engineer should work to minimise environmental impact. This often places *constraints* on a design that rules out certain design options.

The fourth criterion is **social or ethical impact**. Obvious social impacts include noise, dust, visual impact, etc. Less obvious are issues of ergonomics and social inclusivity.

These last three criteria are often referred to as the **Triple Bottom Line**. The traditional bottom line is economic – costs versus benefits. To this, we add measures of environmental and social impact.

Together, these criteria are the **4 E’s**: engineering, economic, environmental and ethical. Engineering’s primary purpose is to serve society. Yet, oddly enough, engineers often don’t think of the impact of their work on society.

Decision making

When it comes to choosing a **preferred alternative** for an engineering project, you need to satisfy all four of the criteria above.

This can be done by using some criteria as **constraints**. We do this all the time with the technical requirements. We do not choose a beam that is of inadequate strength, for instance. Likewise, if a set of solutions cause undesirable social or environmental impact, we rule them out.

This then leaves us with a set of acceptable or **feasible solutions**, from which we need to choose the “best”. At this point we need to make **trade-offs** between different solutions. This is complicated by the fact that the different criteria are measured in different ways and some criteria have no quantifiable measures. (There are no units for beauty, for instance).

At this point, it can be helpful to have input from a range of **stakeholders**. Their views can be gathered through community meetings or consultation.

One methodology for working with multiple criteria using different measures is to assign **scores** (say 1..10) to each of the criteria for each solution and then to **weight** each criterion (again, 1..10). Calculate the total score for each option by multiplying all the weights by the rating scores and adding them up. (This is actually the *dot product* of the rating vector and the weight vector).

Different stakeholders will provide different ratings and weights, and hence they will rank the alternatives in different orders. From all of the consultation, **consensus** on the preferred option or options will hopefully arise.

You can simulate this in your group by using different group members to **play different stakeholder roles**.

Report Writing

Report writing is an important skill for all engineers. It is covered in some detail here and in many excellent books in the library. This document sets out reasonable expectations of your impending Engineering report. Your lecturer may also have other specific requirements.

Overall Structure

Your report is a guide to the client to all the good work that you have done. It is very unlikely that s/he has time to read every word that you write. Consequently, your report must be structured to allow them to find your recommendations quickly, without being overwhelmed by the details of your analyses. The following structure is suggested:

Title page	Title of project, subject, lecturer/tutor, date, your name and student ID, etc.
Executive Summary	One page that sets the problem in context, that draws a boundary around what you have done and that **provides your key outcomes and recommendations**. A reader should not have to read more than the Summary to get your message.
Table of Contents	*Word* will generate this automatically for you if you use *Heading* styles. See how to do this with Word.
Introduction	A more complete introduction to the problem than you provided in the Summary: perhaps half to one page.
Detail sections	One or more sections that provide a detailed walkthrough of your analysis. Keep it simple, with only key charts and equations. You will want to review demonstrate that your work is based on authoritative references. In larger, reports, chapter 2 is often a Literature Review. In briefer reports, the references will be included in the discussion of the methodologies you have used. For more detail, refer the reader to the relevant Appendix where more detail, such as sample calculations, can be provided. These detail sections should be about 3-7 pages.
Conclusion	A summary of what has been done plus your key **recommendations**. This should be about a page.
References	A list, in a standard form, of books and web sites that you have referred to in your report. See The Learning Centre for guidelines for correct referencing standards.
Appendices	Location of your original data and detailed analyses. Keep your Appendices as short as possible and make sure that they are not just a dumping ground for every spreadsheet and chart you have developed. The reader will need a guide to what is there.

Detail

The key questions that you need to answer before you write your report are:

- Why am I writing this?
- Who will read this?

- What do they need to know? What do I want to tell them? What is the message?
- How will I convey it (the message)?

The suggested structure, above, will help somewhat with the last point. However, you will need to plan how you will convey the detail of what you have done.

Start by writing some headings of the key stages in your analysis and the key findings that you have developed. Keep it simple. Put detail in the Appendices. Mindmaps are good ways of planning your report structure, but you can also use *Word*'s outlining capabilities.

Once you have the sequence of main headings right, subdivide them into further detail or write what the main message will be for each heading.

When these messages are clear in your mind, write connected prose to join the sections together.

Add sufficient charts and tables to illustrate your main points.

Write the Conclusions and Recommendations.

Write the Summary. Could I read the Summary (and nothing else) and get the main message and conclusions of your report? If not, it needs more work!

Proofing

You now have a first draft of your final report. It will need rereading and careful editing before it becomes readable. Leave time to do this. Make sure that the story flows from beginning to end. Make sure that your recommendations are clear. Remove extraneous material that does not contribute to your overall recommendations. Move it to an Appendix if it is sufficiently relevant.

Give your report to one of your group members for comment. Proofread their report and make comments.

More information

Project Handbook components (http://project-handbook.pbworks.com/)**:**

- **Making the most of** Microsoft Word
- Referencing
- **Writing Reports** (the extended version) available at: http://project-handbook.pbworks.com/f/Writing+reports+-+longer+version.pdf)

See also:

- **CQ University's Academic Learning Centre** (at their Moodle site)
- **The University of Melbourne's LLSU's AIRport** (https://airport.unimelb.edu.au/gate1/writing/)
- **RMIT's LSU Learning Lab** (https://emedia.rmit.edu.au/learninglab/content/writing-skills)
- **USyd's WRiSE – Writing Reports in Science and Engineering** (http://learningcentre.usyd.edu.au/wrise/)

List of References and/or Bibliography

Referencing is the practice of acknowledging other authors' work. This is essential to provide supporting evidence for your own writing and also as a process of professional honesty.

There are two parts to referencing:

- ✓ In-text Citation
- ✓ List of References

1. In-text Citation

An in-text citation is the acknowledgement of other authors' work. It includes both paraphrasing and making direct quotes. Unless a writer uses language that is particularly appropriate, it is better to paraphrase whenever you can. This shows that you can synthesise the ideas rather than just repeat them.

After you have paraphrased the words or stated the findings of another author in your report, you need to acknowledge where the information came from. At the end of the sentence, you need to include the citation. There are two basic citation methods:

1. the **name and date system**, sometimes called the Harvard system:

   e.g. Skelton poses that all engineers have the legal and moral duty to ensure that a plant designed or operated under their control is as safe as is reasonably practicable (Skelton, 1997).

   Or, written another way:

   Skelton (1997) poses that all engineers have the legal and moral duty to ensure that a plant designed or operated under their control is as safe as is reasonably practicable.

   When using a reference again in the same report [in this case, Skelton (1997)], include the same details at the end of your paragraph.

   e.g. Process industries are in a different situation from most industries, Skelton suggests, because the release of toxic materials or large amounts of energy can result in accidents (Skelton, 1997).

   Each different reference in your report will have a similar citation:

   e.g. the Institution of Chemical Engineers suggests that the success of any safety management lies in the confidence and attitude of its staff (IChemE, 1991).

   References are included in alphabetical order of author at the end of the report.

2. the **numbered system**, sometimes called the Vancouver system:

   e.g. Skelton poses that all engineers have the legal and moral duty to ensure that a plant designed or operated under their control is as safe as is reasonably practicable [1].

   Note that this Handbook uses the Vancouver system.

   References are included in numerical order (i.e., in order of appearance) at the end of the report.

Which system should you use? It depends, of course. Your department or school may specify which system it wants you to use. Likewise, many journals and publishers will require a particular format (and there are a million variations on the two basic systems). Otherwise, many authors and readers prefer the author+date system because it's easy to find an author's work in the list of references, because it's in alphabetical order, and the mere mention of a name of a expert in the field is enough to lend strength to your argument. This is really important in a major work where there may be hundreds of references. The numbered system suits better where the chronological ordering of the references makes more sense, eg, by grouping references by chapter.

2. List of References

Your list of references should only include the texts cited in your report [not any further reading that you may have done]. The references can be found in the reference list ordered alphabetically by name and numerically by year or numerically by appearance in the text, depending on which of the two systems you've used.

References should include the surname of the author and their first name initial, the date of publication in brackets, the title of the book in *Italics*, the place of publication and the publishing organisation:

References

IChemE (1991). *Safety in Chemical Engineering*. UK: Institution of Chemical Engineers

Skelton, B. (1997). *Process Safety Analysis: an Introduction.* UK: Institution of Chemical Engineers

Or

1. Skelton, B. (1997). *Process Safety Analysis: an Introduction.* UK: Institution of Chemical Engineers
2. IChemE (1991). *Safety in Chemical Engineering*. UK: Institution of Chemical Engineers

Software to make it easy – *Word + EndNote*

Keeping track of citations is a problem, particularly in large reports. If you delete a reference in the numbered system, you have to renumber all the later ones. In the name+date system, you have to sort all the references into alphabetical order. It makes sense to use software to make this job easier.

Although all versions of Word have an endnote/footnote capability, which is useful for the numbered system, it did not support the name+date system until 2007.

Word 2007 and later have a citation and referencing system that will store your references and allow you to insert them into your documents.

A separate package, called **EndNote**, is available at many universities. This is a specialised bibliographic system. It allows you to store your papers (e.g. PDFs) and references in a database and also to import references from many library systems. (This saves typing in the author's name, title of the work, date, publisher, etc). Inserting an item in your report is as simple as selecting it in EndNote and clicking on the insert citation button on the EndNote toolbar in Word:

With EndNote you can also reformat all your references from one system to another and accumulate the references that you use regularly, carrying them from one document to another via your reference library. You can also import references from other users.

Check with your Library for regular EndNote classes.

More information

Get EndNote from your university's library site.

Visit the LSU Learning Lab at: http://www.dlsweb.rmit.edu.au/lsu/index.htm +
Click on *Writing Skills* and then *Referencing*.

Making the most of Microsoft Word

(Getting it to do the hard work for you).

Overview

This chapter covers some key ideas about using Word more effectively and efficiently. The point here is to **save time**. My experience suggests that most people don't know these basics.

What will you learn?

1. Setting up a **preferred font** and **paragraph spacing**. Required once only.
2. Using **heading styles** to define the structure of your document. Use **headings** in every document.
3. Creating a **Table of Contents** for your report.
4. Other lessons along the way.

Preferred font

As Word is delivered, the default font varies and is often too small for most work. I use **Calibri, 11 pt**[3] for most work, such as this document. It has is a nice clean and modern typeface.

So, what do we have to do to make this our default, so that **every new document** comes up looking like that rather than using Microsoft's default?

First, you need to understand how Word works.

Word documents are made up of **paragraphs**. A paragraph ends when you press the **Enter** key.

Word attaches a **style** to each paragraph and the default style is called **Normal**, which you can usually see on the toolbar:

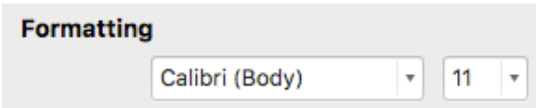
The style selection box on the toolbar

What we must do is **change the characteristics of the Normal style** and save the changes for the next time we use Word.

Modifying the Normal style

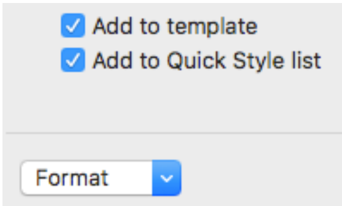
Right click on the **Normal** style in the **Home** tab.

Choose **Modify** from the dropdown menu:



Select the font style and size (at least 11 pt):

Next, check the box that says **Add to Template** to make the change permanent.



Click on **OK** to close the dialog box.

When you change the Normal style, many of the other styles will tend to change with it because they are derived from the Normal style. This is the easiest way to customise your Word documents.

Changes to styles are saved in the default **template**, a file called NORMAL.DOT. When you exit Word, the changes become permanent (or until you change them again as above).

Paragraph spacing

So now we have a decent font to work with and we know it's going to be the same every time we use Word.

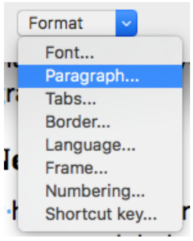
The next thing to set is the **paragraph spacing**.

[3] there are 72 points to the inch (25.4 mm)

Most people I have seen press the Enter key twice at the end of every paragraph – once to end the paragraph and the second time to create white space in front of the next paragraph.

It's much easier to ask Word to provide white space automatically for every paragraph.

So, we need to make another small change to the Normal style: right click on it in the style section of the **Home** tab and choose **Modify**, as before.

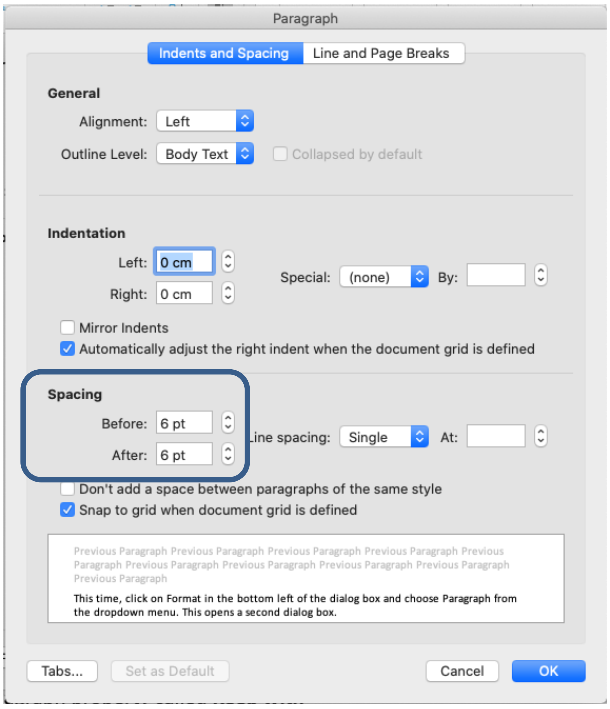


This time, click on **Format** in the bottom left of the dialog box and choose **Paragraph** from the dropdown menu. This opens a second dialog box.

Next, set the paragraph properties in the **Indents and Spacing** tab. I always use 6 pt spacing before and after the Normal paragraphs. (A blank line is about 12 pt).

This gives enough visual spacing between the paragraphs without wasting paper. This page has 6 pt spacing between paragraphs, as an example.

Press **OK**.



On the first dialog box, check the **Add to Template** box, as before, and click **OK**.

Now you just must retrain your brain to not press Enter twice at the end of every paragraph! ☺

Note that before and after spacing is not additive; it's the minimum requirement. So, two adjacent Normal paragraphs will have 6 pt space between them, not 12 pt.

Keep with Next

Have you ever had the problem of dangling headings at the end of a page, with the paragraph belonging to the heading pushed to the next page?

Word has a paragraph property called **Keep with Next** that will drag a heading onto the next page if the next paragraph gets placed there. However, it can't work if there's a blank paragraph between the heading and the next paragraph. That's why you shouldn't use blank paragraphs and why each paragraph needs to have its own **before** space, as described above.

Summary so far

We have now made the most basic customization of Word so it will always give us the right font style and size and basic inter-paragraph spacing. We've made these changes permanent using the **Add to Template** check box. Now it's time to use **Headings**.

Heading styles

Styles are a vital component in the efficient use of ***Word.*** If you don't use them, you are not making good use of the program's capabilities. We've already met the Normal style, which is the default style in Word.

A style generally applies to a **paragraph.** It combines all the attributes of text and the paragraph, e.g., justification, font type, size of font, border, etc. To assign a style to a paragraph, simply click in the paragraph and then choose the style from the list in the ribbon.

The ribbon shows some common styles, many of which you will never use, I expect. These can be removed from the styles pane by right clicking and selecting **Remove from Style Gallery**.

Other styles are accessible through the **Styles Pane** at the right-hand end of the ribbon.

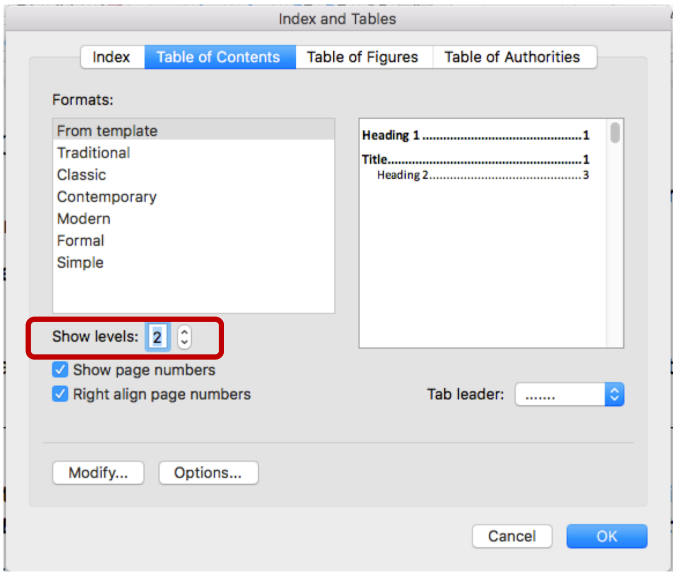
You will quickly discover that a very small number of styles account for 95% of your work. For example, most documents are made up of **Normal, Heading 1, Heading 2**, **Heading 3** and **List paragraph.** (The **Heading** styles allow us to differentiate between headings and text and between headings at different levels).

The **Heading** styles define the hierarchical structure of your document, and they allow *Word* to assemble a Table of Contents for you.

Heading 1 should be used for chapters,
Heading 2 for sections,
Heading 3 for sub-sections, and so on.

Title can be used for the title of your document.

Table of Contents



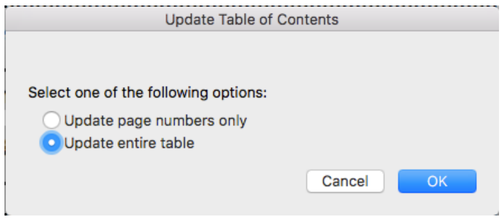
Having defined the Heading styles, Word now knows the structure of your document. You can ask it to compile a Table of Contents for you, which certainly beats doing this by hand!

Choose **Insert** + **Index and Tables** and then the **Table of Contents** tab.

Generally, a Table of Contents with **two levels** is sufficient. Word's default is 3 levels, which is usually too detailed for most reports.

Choose a format that best matches what you want. You can fine tune all the formatting details later by altering the TOC1, and TOC2 styles.

Updating



As you add new sections to your document, or delete old ones, your Table of Contents will need to be updated. Click anywhere in the Table of Contents and press the **F9 key** (or right click in the ToC and select **Update Table**). Choose the option to update the entire table, not just page numbers.

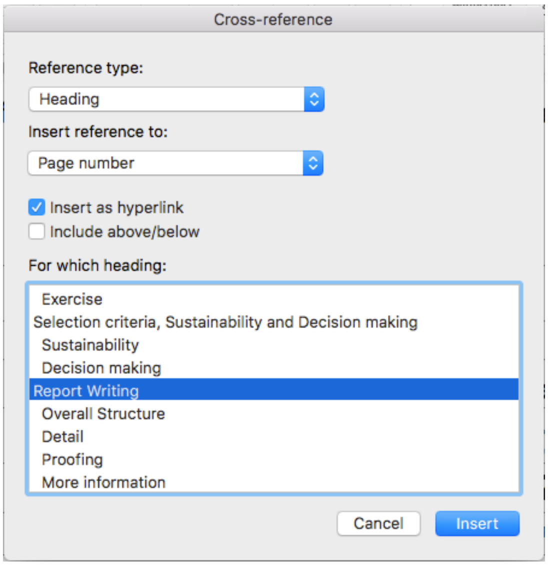
Your Table of Contents will usually be automatically updated when you print.

Customising styles

Now that you've created your first Table of Contents, it's time to learn how to customise the appearance of the various heading styles. We've already seen how to do this for the Normal style. Just repeat for the Heading styles.

- Add some extra space around the Headings to suit your personal taste. Make sure that you use 'before' space, although you may also want to add some extra 'after' space after headings, e.g., 12 pt rather than 6 pt.
- You might always want to start chapters (Heading 1) on a new page. Right-click **Heading 1**, choose **Modify…** then **Format** (bottom left dropdown list) then **Paragraph…** then **Line and Page Breaks** then make sure that **Page break before** is ticked. Don't forget to select **Add to Template** (bottom left) as you exit. This means you only ever have to do this once.
- Also, choose **different fonts and sizes**. Be bold! Choose large font sizes and **never** use underlining; it looks awful in my opinion.
- Make sure that **Keep with Next** is checked for each of the **Heading** styles (but not for the Normal style).

Other Tables



Word will also keep track of Tables of Tables, Figures, Equations, and Index etc. These are all accessed through the **Insert | Index and Tables** menu. To track tables, figures, etc., you will need to use the **Insert + Caption** option for each of your tables and figures. You can customise the appearance of these labels using the **Caption** style (of course)!

You can also insert **cross-references**, which are very useful when you need to refer to a heading, figure, table or page at some other point in the document. Word will keep track of it for you and generate the right page number and table/figure number.

For instance, in this document, you will find information about Report Writing on page 34. I created this by **Insert + Cross-reference** and then the options in the dialog box as shown here:

Useful Shortcut Keys

Style	Windows	Mac
Normal	Shift-Ctrl-N	⌘-Shift-N
List Bullet	Shift-Ctrl-L	⌘-Shift-L
Heading 1	Alt-Ctrl-1	⌘-Option-1
Heading 2	Alt-Ctrl-2	⌘-Option-2
Heading 3	Alt-Ctrl-3	⌘-Option-3

Summary

What have we covered here?

1. Setting up a **preferred font** and **paragraph spacing** by modifying the Normal style.
2. Using **heading styles** to define the structure of your document.
3. Creating a **Table of Contents** for your report using Heading styles.
4. Using **Keep with Next** to avoid dangling headings.
5. Handy **shortcut keys**.

Report Writing

You can use the report template (called REPORT.DOC) to format larger documents. It contains all the necessary formatting (and a table of contents) for a multipage report.

See **Writing Reports** for a discussion of report writing and the use of this template with *Word.* This template should give you some clues to what can be achieved with templates. *Word* comes with many templates.

Summary

This short manual has provided an overview of the key skills required in engineering:

- The Design Process
- Project management
- Groupwork
- Research
- Journals and logbooks
- Presentation skills
- Creativity
- Decision making
- Report writing
- Using MS Word

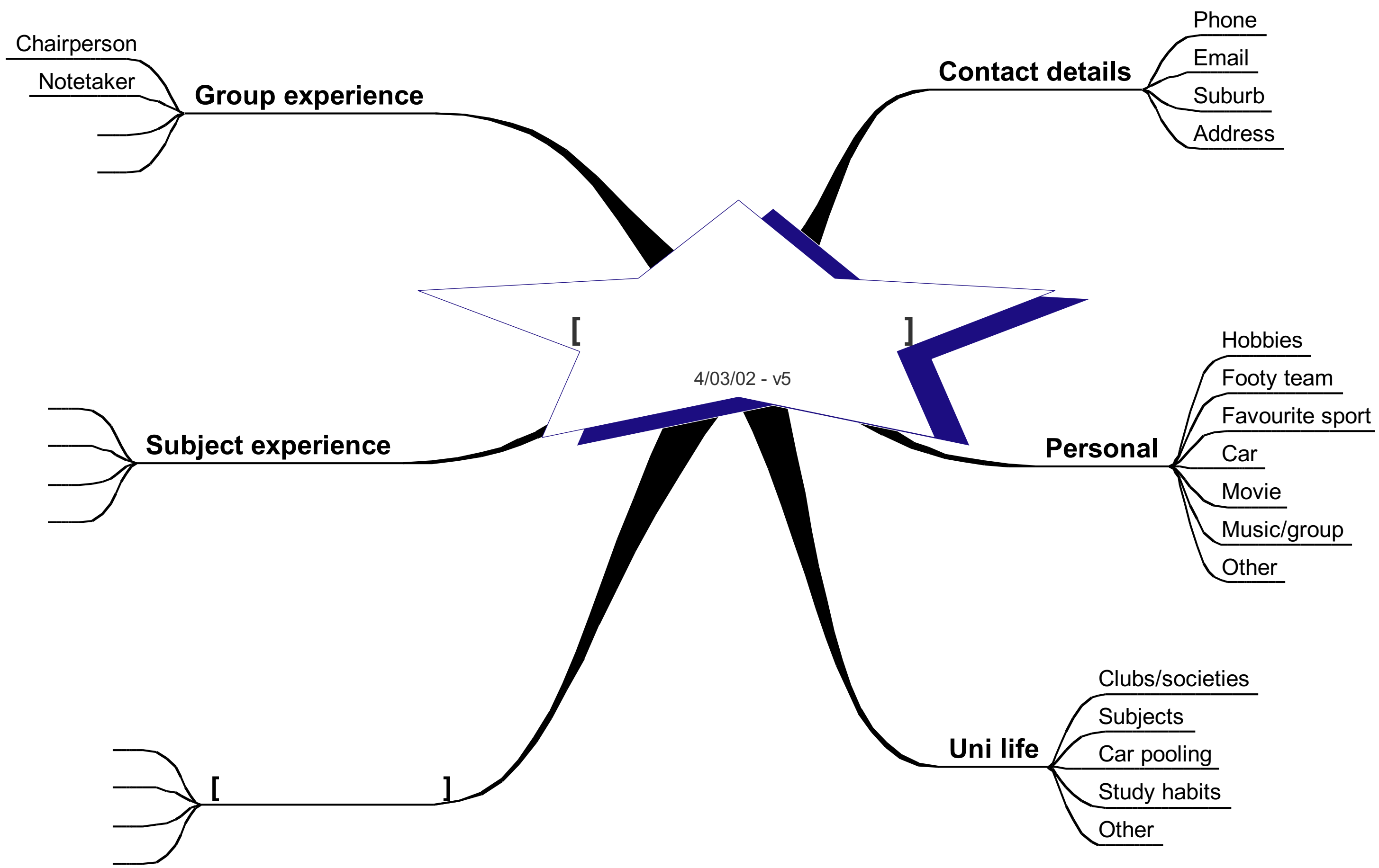
It has pointed to other resources that you will find helpful. There are hundreds of books and websites about each of these topics.

Other useful reading

Trevelyan, James (2021) *Learning Engineering Practice*, CRC Press.

Selinger, C. (2004) *Stuff You Don't Learn in Engineering School: Skills for Success in the Real World*, Wiley-IEEE Press.

about them.


Group experience
Chairperson
Notetaker
Contact details
Phone
Email
Suburb
Address
[ ]
4/03/02 - v5
Subject experience
Personal
Hobbies
Footy team
Favourite sport
Car
Movie
Music/group
Other
[ ]
Uni life
Clubs/societies
Subjects
Car pooling
Study habits
Other

Action Plan

Team .... Date: /   /   Week number ....

Major Task Description	Sub-task description	Who is responsible?	Due date	Status ✓, c/f , ✗	Approx time spent (hrs)

Status: ✓= completed, C/F = carried forward, ✗ = dropped

NOTES:

Team leader signature ____________________

Computation Sheet

Company		**Date:**	
Client		**Designer:**	
Project		**Checker:**	
Design		**Job No.**	

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