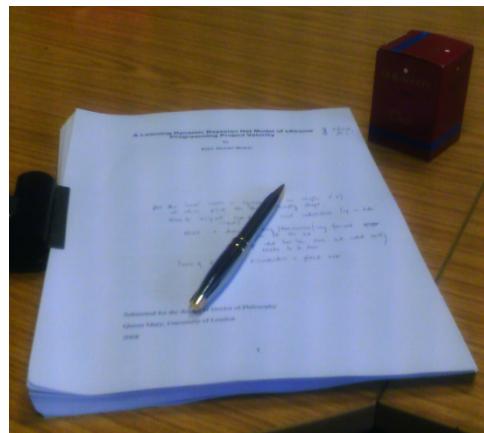


Improving Your Technical Writing Skills

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Abstract

This document describes the basic principles of good writing. It targets primarily students and researchers who have to write technical and business reports. However, the principles are relevant to any form of writing, including letters and memos. Therefore, the document contains valuable lessons for anybody wishing to improve their writing skills. The ideas described here are, apart from minor exceptions, not original. They draw on the ideas in a range of excellent books and from various outstanding authors with whom I have worked. Thus, the approach represents a kind of modern consensus. This approach is very different from the style that was promoted by the traditional English schools' system, which encouraged students to write in an unnecessarily complex and formal way. The approach described here emphasises simplicity ('plain English') and informality. For example, it encourages shorter sentences and use of the simplest words and phrases possible. It explains how you can achieve simplicity by using the active rather than the passive style, personal rather than impersonal style, and by avoiding noun constructs in favour of verbs. Crucially, this approach leads to reports that are easier to read and understand.

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1. Introduction

Look at the following two sentences that provide instructions to a set of employees (this Example is from reference [1]):

1. It is of considerable importance to ensure that under no circumstances should anyone fail to deactivate the overhead luminescent function at its local activation point on their departure to their place of residence, most notably immediately preceding the two-day period at the termination of the standard working week.
2. Always turn the lights out when you go home, especially on a Friday.

The meaning of both sentences is equivalent. Which one was easier to read and understand?

The aim of this document is to show people how to write in the style of the second sentence rather than the first. If you actually prefer the first, then there is little point in you reading the rest of this document. However, please do not expect to win too many friends (or marks) from any writing that you produce.

Unfortunately, the great shame for anybody having to read many reports in their everyday life is that the school system continues to produce students who feel they *ought* to write in a style more like the first sentence than the second. Hence, the unnecessarily complex and formal style is still common. This document shows you that there is a better way to write, using simple, plain English.

One of the good things about technical writing is that you really can *learn* to improve. You should not believe people who say that being a good writer is a natural ability that you either have or do not have. We are talking here about presenting technical or business reports and not about writing novels or poems. I speak from some experience in this respect because, in the last thirty years, I have learned these ideas, and applied them to become a better writer. When I was writing my first book, an outstanding technical editor highlighted the many problems with my writing. I was guilty of many of the examples of bad practice that I will highlight throughout this document. You too can improve your writing significantly if you are aware of what these bad practices are, and how to avoid them.

The document is structured as follows:

- *Before you start writing* (Section 2): This is a simple checklist that stresses the importance of knowing your aim and audience.
- *Using plain English: style* (Section 3). This is the heart of the document because it explains how to write in the simplest and most effective way.
- *Using plain English: the mechanics* (Section 4). This covers vocabulary, spelling, and punctuation.
- *Basic structure for reports* (Section 5). This section explains how to organise your report into sections and how to lay it out.
- *Abstracts and executive summaries* (Section 6). This explains the difference between informative and descriptive abstracts. It tells you why you should always use informative abstracts and how to write them.
- *Writing that includes mathematics* (Section 7). This contains some simple rules you should follow if your writing includes mathematical symbols or formulae.

There is also a summary and conclusions section. The final section, references, also contains additional reading recommendations.

2. Before you start writing

Before you start producing your word-processed report, you must make sure you do the following:

- *Decide on the aim.* This is critical. If you fail to do this, you will almost certainly produce something that is unsatisfactory. Every report should have a single clear aim. Make the aim as specific as possible.
- *Write down the aim.* Ideally, this should be in one sentence. For example, the aim of this document is “to help students write well-structured, easy-to-understand technical reports”. You should state the aim at the beginning of the report. If you cannot write down the aim in one sentence, you are not yet ready to start writing.
- *Always have in mind a specific reader.* Normally you should assume that the reader is intelligent but uninformed, but it is best to be more specific and to state your intended audience. For example, the target readers for this document are primarily students and researchers with a good working knowledge of English. The document is not suitable for children under 13, nor people who have yet to write documents in English. It is ideal for people who have written technical or business documents and who wish to improve their writing skills.
- *Decide what information you need to include.* You should use the aim as your reference, and list the areas you need to cover. Once you have collected the information, make a note of each main point and then sort them into logical groups. Ultimately, you have to make sure that every sentence contributes to the aim. If material you write does not contribute to the aim then remove it – if it is good, you may even be able to reuse it in a different report with a different aim.
- *Have access to a good dictionary.* Before using a word that ‘sounds good’, but you are not sure of its meaning, check it in the dictionary. Do the same for any word that you are not sure how to spell.
- *Identify someone who can provide feedback.* Make sure you identify a friend, relative or colleague who can read at least one draft of your report *before* you submit it formally. Do not worry if the person does not understand the technical area – they can at least check the structure and style, and it may even force you to write in the plain English style advocated here.

You should apply the following checklist before you give even an early draft of your document to a reviewer:

- Check that the structure conforms to all the rules described in this document.
- Run the document through a spelling checker.
- Read it through carefully, trying to put yourself in the shoes of your potential readers.

3. Using plain English: style

When you are producing a technical or business report, you want it to 'get results'. If you are a student, this can mean literally getting a good grade. More generally, we mean that you want to convince the reader that what you have to say is sensible so that they act accordingly. If the report is a proposal for the target readers to do something, then you want the reader to accept your recommendations. If the report describes a piece of research, then you want the reader to understand what you did, and why it was important and valid. Trying to be 'clever' and 'cryptic' in the way you write will confuse and annoy your readers, and have the opposite effect to what you wanted. In all cases, you are more likely to get results if you present your ideas and information in the simplest possible way. This section describes how to do this.

The section is structured as follows:

- Sections 3.1 and 3.2 describe structural techniques for making your writing easier to understand. Specifically:
 - Sentence and paragraph length: keeping them short is the simplest first step to improved writing.
 - Bullet points and lists: using these makes things clearer and less cluttered.
- Sections 3.3 and 3.4 describe techniques for using fewer words. Specifically:
 - Using the simplest words and expressions available: this section also describes words and expressions to avoid.
 - Avoiding word redundancy.
- Sections 3.5 to 3.7 describe techniques for avoiding common causes of poorly structured sentences. Specifically:
 - Using verbs instead of nouns.
 - Using active rather than passive style.
 - Using personal rather than impersonal style.
- Section 3.8 describes how to explain new ideas clearly.
- Section 3.9 explains the importance of naming things consistently.
- Section 3.10 gives some rules on how not to offend the politically correct - without adding complexity.

3.1 Sentence and paragraph length

Contrary to what you may have learnt in school, there is nothing clever about writing long, complex sentences. For technical writing, it is simply **wrong**. You must get used to the idea of writing sentences that are reasonably short and simple. In many cases, you can write shorter sentences by sticking to the following principles:

1. A sentence should contain a single unit of information. Therefore, avoid compound sentences wherever possible. In particular, be on the lookout for words like *and*, *or*, and *while* which are often used unnecessarily to build a compound sentence.
2. Check your sentences for faulty construction. Incorrect use of commas (see Section 4.3 for how to use commas correctly) is a common cause of poorly constructed and excessively long sentences.

Example (this example also fixes some other problems that we deal with later)

Bad: "Time division multiplexed systems are basically much simpler, the combination and separation of channels being affected by timing circuits rather than by filters and inter-channel interference is less dependent on system non-linearities, due to the fact that only one channel is using the common communication medium at any instant."

Good: "Systems multiplexed by time division are basically much simpler. The channels are combined and separated by timing circuits, not by filters. Interference between channels depends less on non-linear features of the system, because only one channel is using the common communication medium at any time."

3. Use parentheses sparingly. Most uses are due to laziness and you can avoid them by breaking up the sentence. **Never** use nested parentheses if you want to keep your reader.

Learning about some of the principles described below, especially using active rather than passive constructs, will go a long way toward helping you shorten your sentences.

Just as it is bad to write long sentences, it is also bad to write long paragraphs. A paragraph should contain a single coherent idea. You should always keep paragraphs to less than half a page. On the other hand, successive paragraphs that are very short may also be difficult to read. Such an approach is often the result of poorly structured thinking. If you need to write a sequence of sentences that each express a different idea, then it is usually best to use bullet points or enumerated lists to do so. We consider these next.

3.2 Bullet points and enumerated lists

If the sentences in a paragraph need to be written in sequence it suggests that they are related and form some kind of a list. You should use the idea that relates to introduce the list. For example, the following paragraph is a mess because the writer is trying to make what is clearly a list into one paragraph:

Getting to university on time for a 9.00am lecture involves following a number of steps. First of all you have to set your alarm – you will need to do this before you go to bed the previous night. When the alarm goes off you will need to get out of bed. You should next take a shower and then get yourself dressed. After getting dressed you should have some breakfast. After breakfast you have to walk to the tube station, and then buy a ticket when you get there. Once you have your ticket you can catch the next train to Stepney Green. When the train arrives at Stepney Green you should get off and then finally walk to the University.

The following is much simpler and clearer:

To get to university on time for a 9.00am lecture:

1. Set alarm before going to bed the previous night
2. Get out of bed when the alarm goes off
3. Take a shower
4. Get dressed
5. Have some breakfast
6. Walk to the tube station
7. Buy ticket

8. Catch next train to Stepney Green
9. Get out at Stepney Green
10. Walk to the University

The simple rule of thumb is: if you are describing a list, display it as a list.

The above is an example of an **enumerated** list. The items need to be shown in numbered order. If there is no specific ordering of the items in the list then you should use bullet points instead. For example, consider the following paragraph:

Good software engineering is based on a number of key principles. One such principle is getting a good understanding of the customer requirements (possibly by prototyping). It is also important to deliver in regular increments, involving the customer/user as much as possible. Another principle is that it is necessary to do testing throughout, with unit testing being especially crucial. In addition to the previous principles, you need to be able to maintain good communication within the project team (and also with the customer).

The paragraph is much better when rewritten using bullet points:

Good software engineering is based on the following key principles:

- Get a good understanding of the customer requirements, possibly by prototyping.
- Deliver in regular increments, involving the customer/user as much as possible.
- Do testing throughout (unit testing is especially crucial).
- Maintain good communication within the project team (and with the customer).

Throughout this report, there are numerous bullet points and enumerated lists. You should not be scared to use such lists. Also, note the following rule for punctuation in lists:

If all the list items are very short, by which we normally mean less than one line long, then there is no need for any punctuation. Otherwise, use a full stop at the end of each list item.

3.3 Using the simplest words and expressions possible

On a recent trip to Brussels by Eurostar, the train manager made the following announcement: “Do not hesitate to contact us in the event that you are in need of assistance at this time”. What she meant was: “Please contact us if you need help now”, but she clearly did not use the simplest words and expressions possible. While this may be acceptable verbally, it is not acceptable in writing.

The golden rules on words and expressions to avoid are:

- Replace difficult words and phrases with simpler alternatives;
- Avoid stock phrases;
- Avoid legal words and pomposity;
- Avoid jargon.

We will deal with each of these in turn.

3.3.1 Replace difficult words and phrases with simpler alternatives

Table 1 lists a number of words and expressions that you should generally avoid in favour of the simple alternative.

Table 1 Words and expressions to avoid

Word/phrase to avoid	Simple alternative	Word/phrase to avoid	Simple alternative
utilise	use	endeavour	try
facilitate	help	terminate	end, stop
at this time	now	transmit	send
in respect of	about	demonstrate	show
commence	start	Initiate, commence	begin
terminate	end, stop	assist, assistance	help
ascertain	find out	necessitate	need
in the event of	if	in excess of	more than
in consequence	so	erroneous	wrong
enquire	ask	render	make

The only time you should use any of these words is when they have a specific well-defined technical interpretation. For example, the word “render” does have a specific technical meaning in the context of building maintenance (as when you ‘render’ a wall) and in computer graphics (as when you ‘render’ an image). However, you should never use the verb ‘render’ when what you really mean is ‘make’. Thus, while many pompous writers would think they were being clever by writing a sentence like:

The testing strategy rendered it impossible to find all the faults.

What they really mean is the much simpler:

The testing strategy made it impossible to find all the faults.

3.3.2 Avoid stock phrases

You should avoid stock phrases, like those shown in Table 2, in reports and letters in favour of the simpler alternative. Such phrases are cumbersome and pompous.

Table 2 Stock phrases to avoid

Bad	Good
There is a reasonable expectation that ...	Probably ...
Owing to the situation that ...	Because, since ...
Should a situation arise where ...	If ...
Taking into consideration such factors as ...	Considering ...
Prior to the occasion when ...	Before ...
At this precise moment in time ...	Now ...
Do not hesitate to ...	Please ...
I am in receipt of ...	I have ...

3.3.3 Avoid legal words and pomposity

Lawyers seem to have a language of their own. This is primarily to ensure that their documents are so difficult to understand that only other lawyers can read them. This ensures more work and money for lawyers because it forces ordinary people to pay them for work they could do themselves. Yet, for some strange reason ordinary people often think they are being very clever by using legal words and expressions in their own writing. Do not fall into this trap. Avoid legal words like the following:

forthwith	hereof	Of the (4 th) inst.	thereof
henceforth	hereto	thereat	whereat
hereat	herewith	therein	whereon

Also avoid nonsensical legal references like the following:

“The said software compiler...”

which should be changed to

“The software compiler...”

and:

“The aforementioned people have agreed ...”

which should be changed to

“A and B have agreed...”

3.3.4 Avoid jargon

Expressions like *RAM*, *Poisson distribution*, *FA Cup*, and *distributor cap* are examples of jargon. In general, jargon refers to descriptions of specific things within a specialised field. The descriptions are often shorthand or abbreviations. If you are certain that every reader of your report understands the specialist field then it can be acceptable to use jargon. For example, if your only potential readers are computer specialists then it is reasonable to refer to *RAM* without the need to explain what *RAM* is or stands for. The same applies to *Poisson distribution* if your readers are all statisticians, *FA Cup* if your readers are British football fans, or *distributor cap* if your readers are car mechanics. In all other cases (which is almost always) you should avoid jargon. If you cannot avoid it by using alternative expressions, you should define the term the first time you use it and/or provide a glossary where you give the definitions.

3.4 Avoiding unnecessary words and repetition

Many sentences contain unnecessary words that repeat an idea already expressed in another word. This wastes space and blunts the message. In many cases, unnecessary text is caused by ‘abstract’ words like *nature*, *position*, *character*, *condition* and *situation* as the following examples show:

Bad	Good
The product is not of a satisfactory <u>nature</u>	The product is unsatisfactory
The product is not of a satisfactory <u>character</u>	The product is unsatisfactory
After specification we <u>are in a position to</u> begin detailed design	After specification we can begin detailed design

We are now in the situation of being able
to begin detailed design

We can now begin detailed design

In general, you should use such abstract words sparingly, if at all.

Often writers use several words for ideas that can be expressed in fewer. This leads to unnecessarily complex sentences and genuine *redundancy* as the following examples show:

With redundancy

The printer is located next to the computer
 The printer is located in the immediate vicinity of the computer
 The user can visibly see the image moving
 He wore a shirt that was blue in colour
 The input is suitably processed
 This is done by means of inserting an artificial fault
The reason for the increase in number of faults found was due to an increase in testing
 It is likely that problems will arise with regards to the completion of the specification phase
Within a comparatively short period we will be able to finish the design

Without redundancy

The printer is next to the computer
 The printer is near the computer
 The user can see the image moving
 He wore a blue shirt
 The input is processed
 This is done by inserting an artificial fault
 The increase in number of faults found was due to an increase in testing
 You will probably have problems completing the specification phase
 Soon we will be able to finish the design

Another common cause of redundant words is when people use so-called *modifying* words. For example, the word *suitable* in the sentence “John left the building in suitable haste” is a modifying word. It is redundant because the sentence “John left the building in haste” has exactly the same meaning. Similarly, the other form of a modifying word – the one ending in ‘y’ as in *suitably* – is also usually redundant. For example, “John was suitably impressed” says nothing more than “John was impressed”. Other examples are:

Bad

absolute nonsense
absolutely critical
considerable difficulty
considerably difficult

Good

nonsense
 critical
 difficulty
 difficult

Modifying words can be fine when used with a concrete reference, as in the example “Jane set John a suitable task” but in many cases, they are not and so you should avoid them: Here are the most common modifying words to avoid:

appreciable	excessive	sufficient	comparative	negligible
approximate	fair	suitable	definite	reasonable
utter	relative	undue	evident	

Finally, one of the simplest ways to shorten and simplify your reports is to remove repetition. If you describe the same idea in different places then you will likely end up with a poorly structured report (indeed it is one of the characteristics of poorly structured reports). The only ‘allowable’ repetition is in introductions and summaries, as we shall see in Section 5.4. You can avoid repetition by checking through your report and jotting down a list of the key ideas as they appear. Where the same idea appears more than once, you have to decide the place where it should best go and then delete and/or merge the text accordingly.

3.5 Using verbs instead of nouns

Look at the following sentence:

“Half the team were involved in the development of system Y”.

This sentence contains a classic example of a common cause of poor writing style. The sentence is using an abstract noun ‘development’ instead of the verb ‘develop’ from which it is derived. The simpler and more natural version of the sentence is:

“Half the team was involved in developing system Y”.

Turning verbs into abstract nouns always results in longer sentences than necessary, so you should avoid doing it. The following examples show the improvements you can achieve by getting rid of nouns in favour of verbs:

Bad	Good
He used to help in <u>the specification of</u> new products	He used to help specify new products
Acid rain accounts for <u>the destruction of</u> ancient stone-work	Acid rain destroys ancient stone-work
When you take into <u>consideration</u> ...	When you consider ...
Clicking the icon causes <u>the execution of</u> the program	The program executes when the icon is clicked
<u>Measurement of</u> the material density was performed by the instrument	The instrument measured the material density
<u>The analysis of</u> the data was performed by Fred	Fred analysed the data
<u>The testing of</u> the product was carried out by Jane	Jane tested the product
It was reported by Jones that method x facilitated <u>the utilisation of</u> inspection techniques by the testing team	Jones reported that method x helped the testing team use inspection techniques

The last example is a particular favourite of mine (the bad version appeared in a published paper) since it manages to breach just about every principle of good writing style. It uses a noun construct instead of a verb and it includes two of the forbidden words (facilitated, utilisation). However, one of the worst features of this sentence is that it says “It was reported by Jones” instead of simply “Jones reported”. This is a classic example of use of *passive* rather than *active* constructs. We deal with this in the next section.

3.6 Using active rather than passive style

Consider the following two sentences:

1. Joe tested the product
2. The product was tested by Joe

Both sentences provide identical information. The first is called the *active* style and the second is called the *passive* style. In certain situations, it *can* make sense to use the passive style. For example, if you really want to stress that a thing was acted on, then it is reasonable to use the passive style as in “the city was destroyed by constant bombing”. However, many writers *routinely* use the passive style simply because they believe it is more ‘formal’ and ‘acceptable’. It is not. Using the passive style is the most common reason for poorly structured sentences and it *always* leads to longer sentences than are necessary. Unless you have a very good reason for the change in emphasis, you should always write in the active style.

The following examples show the improvements of switching from passive to active:

Bad	Good
The report was written by Bloggs, and was found to be excellent	Bloggs wrote the report, and it was excellent
The values were measured automatically by the control system	The control system measured the values automatically
It was reported by the manager that the project was in trouble	The manager reported that the project was in trouble
The precise mechanism responsible for this antagonism cannot be elucidated	We do not know what causes this antagonism
The stability of the process is enhanced by co-operation	Co-operation improves the stability of the process

3.7 Using personal rather than impersonal style

Saying

“My results have shown...”

is an example of a sentence using the personal (also called *first person*) style. This contrasts with:

“The author’s results have shown...”

which is an example of the impersonal (also called *third person*) style.

Whether to use personal or impersonal style is a subject that still causes fierce debate. Some writers feel that a report is not truly scientific if it is written in the personal style, and they back up this claim by pointing to prestigious scientific journals that insist on third person writing. In fact, it is increasingly hard to find any reputable journal that continues with such a policy.

The most important justification for using first person style is that it is more natural and results in simpler sentences. Many examples of the kind of poor sentence structure that we have seen in the previous two sections (using passive rather than active style and using nouns rather than verbs) are the result of writing in the third person. Consider the following examples:

Bad

The current research work of the author of this report is also described

In the previous report of the authors the rationale for the proposed method was discussed in detail

However, it is the writer's belief that this situation should not have occurred

Examination and discussion of the results obtained, are necessary before a decision can be taken

Good

I also describe my current research work

In our previous report we discussed in detail the rationale for the proposed method

However, I believe this situation should not have occurred

We must examine and discuss the results before we decide

In many cases you have to include excruciating diversions to make what you are trying to say unambiguous if you insist on the impersonal style. For example:

“The author's results have shown ...”

may actually be ambiguous because it is no longer clear to which author you refer. This leads to the contorted refinement:

“The results by the author of this report show ...”

which sounds pompous and unnatural. It certainly compares poorly with

“My results have shown...”

In the following example:

“Recent experiments involving formal inspections have resulted in ...”

it is not clear whether the writer is referring to their own experiments, other researchers' experiments, or a combination of the two.

Even worse than ambiguity is where use of impersonal, rather than personal, style introduces genuine uncertainty. For example, consider the following:

“It is not possible to state the exact mode of operation of the drug”.

This leaves serious doubts in readers' minds. It might mean that the authors do not know how the drug works, but it might also mean that it is impossible to specify the operation of the drug.

Finally, many authors who are reluctant to use the personal style, but realise that they cannot write a sentence naturally without it, opt to use the expression 'one' as in “One can conclude from the experiment ...”. You should avoid this, as it sounds pompous. If you feel uneasy about saying “I” then say “we”. In other words, the ‘royal’ we is better than the royal ‘one’.

3.8 Explain new ideas clearly

If you are trying to introduce or explain a new idea or abstract concept, then there are three techniques you can use to help your readers, and improve your message:

- *Use examples:* In Section 3.6 I described the concepts of active and passive constructs. Before attempting a formal definition, I provided some examples. Look back at how I did this and apply the same approach in your own reports. The

general rule is to try to provide an example before providing an abstract definition or generalisation.

- *Use analogies:* Suppose you wanted to explain what email was to somebody who had just woken from a 40-year coma. You could try telling them that email was much like sending a letter, but without having physically to use a stamp and find a letterbox. This is an example of an analogy.
- *Use a diagram:* If you can provide a simple diagram that captures an abstract concept, you are effectively providing a pictorial analogy. This can be effective if done well.

3.9 Use consistent naming of the same ‘things’

Many generations of schoolchildren have been indoctrinated with the rule: “Never use the same word twice”. So, we get writers who feel that they must always use a different word to describe the same thing. In technical and business writing, exactly the opposite rule applies: You should *always* use the same word to refer to the same thing. Anything else causes confusion and annoyance to readers.

Consider, for example, the following paragraph that appeared in a group project final report:

In the first three weeks of the project we wrote a project plan for the system. We were ambitious in our requirements because we wanted the group project to be a success and we wanted the software to be of high quality. In fact we were determined that our software would win the prize. By the end of term we realised there were major problems with the project. The first increment of the project we delivered was inconsistent with the requirements specification and it was clear the final code would not be the best system as there were clearly better groups than ours.

The problem with this paragraph is that the authors refer to three key ‘things’ in different and inconsistent ways. The ‘things’ are:

- *The project:* This refers to the entirety of the group experience.
- *The plan:* This refers to a document describing the requirements and schedule for implementing them.
- *The system:* This refers to the software system that the group project is supposed to deliver.

Unfortunately, we find that the authors refer to these things at different parts of the paragraph as:

- The project: *project; group project; group.*
- The plan: *project plan; requirements; requirements specification.*
- The system: *system; software; project; code; final code.*

Not only is there inconsistent naming of the same ‘things’ but we also find genuine ambiguity because the same words are used to refer to different ‘things’.

There appear to be two distinct reasons why students write in this way:

1. They have been brainwashed by the ‘never use the same word twice’ rule at school.

2. They are genuinely confused in their own minds and therefore hide their confusion by deliberate ambiguity.

In situations such as this, it is important to identify each *different ‘thing’* first and decide how to name it. Once you have made this decision, be consistent and use the same name throughout when you refer to that ‘thing’. In the above example this would lead to the following improved text:

In the first three weeks of the project we wrote a plan for the system. Our plan was ambitious because we wanted the project to be a success and we wanted the system to be high quality. In fact we were determined that our project would win the prize. By the end of term we realised there were major problems with the project. The first increment of the system we delivered was inconsistent with the plan and it was clear the final system would not be the best system as there were clearly better systems than ours.

3.10 Painless political correctness

If you were writing a manual on ‘how to impress the boss’ where the manual is supposed to be relevant for any boss/employee relationship, you would probably want to avoid the following kind of statements:

If you find yourself with little to do ask your boss if he wants you to help him.

The use of ‘he’, ‘she’, ‘him’, ‘her’, when referring to non-specific people can in fact be avoided, without having to resort to the awful ‘he/she’, ‘him/her’ alternative. You can use the following methods:

- Use plural pronouns instead of singular. Thus, use ‘they’ in place of ‘he’ or ‘she’, use the pronoun ‘them’ in place of ‘him’ or ‘her’, and use the pronoun ‘their’ in place of ‘his’ and ‘her’. So the above text could be rewritten as

‘...ask your boss if they want you to help them’.

Similarly, instead of ‘the programmer should test his own code’ you could ‘the programmer should test their own code’.

- Rewrite the sentence in the plural. Thus, instead of ‘England expects every man to do his duty’ write ‘England expects everyone to do their duty’.
- Use ‘you’ or ‘your’. Thus, instead of saying ‘every employee should leave his desk tidy’ say ‘leave your desk tidy’.
- Rewrite the sentence to avoid any reference to awkward pronouns. Often, such an alternative is simpler anyway. For example, you could write ‘If you find yourself with little to do, ask if the boss wants some help’.

3.11 Summary

The main points you should have learnt from this section (in order of importance) are:

- Keep sentences and paragraphs short.
- Never use a complicated word or phrase when there is a simpler alternative.
- Remove any unnecessary words and repetition.
- Use active rather than passive style.

- Use active verbs rather than abstract nouns.
- Use personal rather than impersonal style.
- Explain new ideas clearly by using examples, analogies, and diagrams.
- If what you are describing is a list then use an enumerated list or bullet points.
- Avoid stock phrases, legal words and pomposity.
- For each abstract ‘thing’ referred to in your report, use a consistent name to refer to the ‘thing’. In other words ignore the ‘rule’ that says you should never use the same word twice.
- It is easy to avoid using ‘he’ or ‘she’ to refer to non-specific people and hence avoid upsetting those who view it as politically incorrect.
- Never use the words *utilise* or *facilitate* since these are respectively the most useless and pompous words in the English language.

4. Using plain English: the mechanics

Section 3 explained the most important principles for improving the style of your writing. However, it is also important (and actually easier) to improve the mechanics. We have already looked at the mechanics of structuring reports in Section 2. In this section, we look at the mechanics of using plain English. We focus on:

- Avoiding common vocabulary and spelling errors (Section 4.1)
- Abbreviations (Section 4.2)
- Punctuation (Section 4.3)

4.1 Avoiding common vocabulary and spelling errors

Beyond having a good dictionary available, there is no simple guideline to follow to make sure you always use and spell words correctly. However, some words (see Table 3) are frequently misused in place of similar sounding ones with different meaning.

Table 3: Commonly confused words

affect : verb meaning to influence	effect : noun meaning result or verb meaning to bring about
adverse : adjective meaning unfavourable	averse : adjective meaning opposed to or disinclined
principle : noun meaning a standard or rule of conduct	principal : adjective or noun meaning most important
stationery : noun meaning writing materials	stationary : adjective meaning not moving
illicit : adjective meaning illegal	elicit : verb meaning to give rise to
flaunt : verb meaning to show off	flout : verb meaning to show contempt
allusion : noun meaning a passing reference as in “were you making an allusion to my wife?”	illusion : noun meaning a false impression
complement : noun meaning something that completes, or verb meaning to make complete	compliment : noun meaning praise or verb meaning to praise
council : noun meaning an assembly	counsel : verb meaning to recommend or noun meaning recommendation
ensure : verb meaning to make certain	insure : verb meaning to protect against risk
mitigate : verb meaning to moderate	militate : verb meaning to influence (for or against)
practice : noun as in “put my ideas into practice”	practise : verb
advice : noun meaning recommendation	advise : verb

Similarly, Table 4 lists some of the most commonly misspelt words.

Table 4: Commonly misspelt words

accommodate	embarrass	necessary
commemorate	gauge	parallel
commitment	harass	privilege
committee	mileage	questionnaire

The final class of vocabulary problems you should avoid is using American spelling (unless you are submitting your report to an American audience). This means in particular:

- You should not write words like 'colour' and 'flavour' as 'color' and 'flavor'.

For many verbs that end in 'ise' (such as specialise, generalise, etc.) it is actually OK to use the American ending 'ize' providing that you are consistent.

4.2 Abbreviations

The rules you should follow on abbreviations are:

- Always avoid abbreviating words out of laziness. For example:

Never write 'approx.' for 'approximately' (it may be better to write 'about');

Never write 'e.g.' for 'for example'.

An exception, but misused example, is 'etc.'. However, you can avoid using 'etc.' in most cases. For example, people usually use it in the following way:

"He eats lots of fruit, such as apples, oranges, bananas, etc."

The 'etc.' here is redundant because of the 'such as'. If you are using 'etc.' then the correct way to write the above sentence would be:

"He eats lots of fruit: apples, oranges, bananas, etc."

- A long title, such as Tottenham Hotspur Football Club, should not be abbreviated if it is used only once in a document. However, if it is used more than once then you can abbreviate it to its initials THFC providing that the first time it is used you write the full title with the initials in brackets or vice versa.
- Where initials such as THFC are used, as above, it is useful to provide a glossary.

4.3 Punctuation

This subsection covers the rules for using:

- Capital letters
- Apostrophes
- Commas
- Exclamation marks

4.3.1 Capital letters

People use capital letters far more frequently than they should. Apart from at the beginning of sentences, and proper names, the only other times you need to use capitals are for:

- Organisations and places (for example, the House of Commons);
- Acts of Parliament (for example, the Act of Union);

- Label formed from a proper name (hence Marxist, but not communist);
- North, South, East and West when they form part of a country name but not otherwise (hence South Africa, but south London);
- Titles when used with the name but not otherwise (hence the Duke of York, but not the duke);
- Certain periods of history (for example, the Dark Ages, Renaissance);
- God.

4.3.2 Apostrophes

Apostrophes have two purposes only:

1. **To show that a letter has been missed out:** For example, isn't (is not), can't (cannot), it's (it is).
2. **To show possession:** For example, *the snake's eyes, the child's shoes*. If the thing doing the possessing already has an s at the end then do not add an s. For example, if we are talking about the eyes of several snakes then we write: *the snakes' eyes*. The only exception to this last rule is if:
 - it is a proper noun (Mr Jones's daughter);
 - the word ends in a double ss (the boss's office).

You never use an apostrophe with a possessive pronoun like hers, its, theirs, ours.

If you learn these two simple rules then you should know immediately that the following examples are **wrong** (yet they are extremely common):

- I gave the cat it's food
- I like tomatoe's
- In the 1960's
- All the department's were represented.

In each case the apostrophe should not be there. A related mistake, which is appalling in its stupidity yet incredibly common, is:

- I should of done my homework
- instead of
- I should've done my homework (short for *should have*).

4.3.3 Commas

Commas help the reader to understand the writing more easily. If, when speaking, there would be a slight pause, then there should be a comma. However, if you follow the principles described in Section 3, you will find that you need to use fewer commas because you are writing shorter sentences. Apart from the case where a sentence would be too long otherwise, there are just four reasons for using a comma:

1. **Where you are writing a list.** For example: 'I like apples, oranges, peaches and bananas.' However, note that in technical reports it is usually better to use

enumerated lists or bullet points. Where the items in the list include commas themselves you should use semi-colons rather than commas to separate the list items as in: “Government departments such as health; agriculture, food and fisheries; the foreign office and employment.”

2. **Where you are using a qualifying word or expression at the beginning of a sentence**, such as:
 - However, it is best...
 - For example, we can see ...
 - Unfortunately, you should know...
 - Firstly, it is unlikely ...
3. **Where the sentence would be ambiguous without it.** For example: “I decided on an alteration of course” means that you changed your course, whereas: “I decided on an alteration, of course” means that, naturally, you decided to make an alteration.
4. **To show where you have inserted a phrase.** For example: “Teddy, who is normally the best in the team, had a very poor match.” In any such case, the sentence should still make sense if you remove the part between the commas.

4.3.4 Exclamation marks

There are only two reasons ever to use an exclamation mark:

1. **Where there is an exclamation** as in “Do it now!” or “Help!”
2. **As the mathematical notation for the factorial function**, as in “the number 4! is equal to 4 times 3 times 2 times 1”

You should never use an exclamation mark at the end of a sentence to indicate that the sentence was supposed to be funny. Many people do this, but it is pointless and annoying. If the sentence were funny, the reader should have found it funny without you having to tell them to laugh. If the sentence were not funny, the exclamation mark will have simply confirmed to the reader that you are a poor writer. Either way you lose in the eyes of the reader.

4.3.5 Punctuation after text in inverted commas or brackets

For sentences that include text in inverted commas or brackets, the normal convention is that commas and full stops appear after, rather than before, the closing inverted commas or brackets. Thus, for example, we write:

- The lady said: “I’m feeling unwell”. Then she collapsed.
- The lady said: “I’m feeling unwell”, and then she collapsed.
- The lady collapsed (after feeling unwell).

However, it is worth noting that some US publishers use the opposite convention, as in:

- The lady said: “I’m feeling unwell.” Then she collapsed.
- The lady said: “I’m feeling unwell,” and then she collapsed.
- The lady collapsed (after feeling unwell.)

4.4 Summary

- The only certain way to avoid spelling errors and incorrect vocabulary is to use a dictionary whenever you are unsure of anything. However, there are common examples of words that cause errors and you can learn these.
- Use English rather than American English spelling and punctuation conventions, unless you are targeting an American audience. But note: there are some words – such as the word ‘targetting’ just used - that spellcheckers automatically change to the American version ‘targeting’ even if the spellchecker is set to English.
- You should use abbreviations only where necessary.
- You should use apostrophes only to show possession or to show that a letter has been missed out. All other uses (especially when used before the ‘s’ in plurals) are wrong.
- There are simple rules to learn for when to use commas. In general, however, writing shorter sentences means using fewer commas.
- Apart from its special use in mathematics, you should only use an exclamation mark in an exclamation. Never use it to tell the reader that a sentence was supposed to be funny.

5. Basic structure for reports

Although this document is primarily about improving the content of your writing (by understanding principles of good style), it is important that you learn the required structure of a technical or business document. The section covers the following:

- What every report should contain (Section 5.1)
- General layout (Section 5.2)
- Sections and section numbering (Section 5.3)
- The role of introductions (Section 5.4)
- Figures and tables (Section 5.5)
- Special section about student project reports (Section 5.6)

5.1 ***What every report should contain***

Make sure *every* report contains the following basic information:

- Title
- Author name(s), affiliation and contact details
- Date
- Version number (if the report is likely to be updated by either you or a colleague)
- Page numbers (if the report is more than two pages)

The first four items above must appear on the front page. It is incredible how many reports fail to contain this basic information. Many students, for example, often even fail to put their *name* on their reports.

Reports of more than seven pages should normally also include:

- Abstract, which is essentially an executive summary (it can appear on the front page or before the table of contents).
- Table of contents
- Conclusions
- Acknowledgements and references

Ideally, each page should have a header and a footer (in Microsoft Word you create headers and footers from the *View* menu). The header should contain the author, title, and version number. The footer should contain the date and page number.

Page numbers should appear preferably in the form “Page *n/m*” where *m* is total number of pages. In Microsoft Word it is easy to generate the number corresponding to total number of pages automatically – just select the menu option “*Insert* → *Page Number*” and choose from the various options provided.

You should generate the table of contents automatically. In Microsoft Word the menu option “*References* → *Table of Contents*” provides the required functionality. An automatically generated table of contents will pick up headings that you have nominated as sections and subsections etc.

Any report that is subject to a review procedure should also contain a ‘change history’ page, where you list the version numbers and dates with the main changes made.

5.2 General layout

You should obviously try to make your report attractive to look at. However, this does *not* mean adding meaningless frills such as decorative borders or unnecessary graphics, which actually detract from your message. Figures and tables (see Section 5.5) are excellent for breaking up text, providing that they are genuinely helpful in clarifying your argument or better still, if you use them instead of a long-winded textual description. You should also break the report up with sections and headings, as described in Section 5.3.

One of the simplest ways to make your report attractive is by sticking to the following principles about fonts, spacing and margins:

- *Fonts*: Apart from headings and caption labels, you should generally use the same font and font size throughout. The *Arial* font at 11pt is a good choice.
- *Spacing*: It is good to have plenty of white space on a page. However, double-spacing throughout is overkill, unless you are producing a draft that you want somebody to annotate. Using a font like Arial with the spacing set as *single* in MS Word looks fine (that is how this document is set up). However, what is crucial is that you should always leave spaces between paragraphs. In this document the space between paragraphs is defined by setting *Format → Paragraph → Spacing After* to 6pt in Microsoft Word. That way when you start a new paragraph the correct space is automatically inserted, without you having to use the carriage return to create space between paragraphs.
- *Margins*: Leave wide margins (1.25in is good). For formal reports it is also useful to use the ‘right justify’.

5.3 Sections and section numbering

Any report longer than four pages should be broken up into sections using the following principles:

- Sections should be numbered (preferably using numerals. 1, 2, 3,...). Whatever numbering convention you use must be consistent.
- Each section should have a proper heading that accurately reflects the material contained within it.
- Long sections should be broken up into subsections, which should be numbered $n.1$, $n.2$, etc. where n is the section number.
- Long subsections should be broken up into subsubsections which should be numbered $n.m.1$, $n.m.2$, etc where n is the section number, m is the subsection number.
- Never use numbered decomposition smaller than subsubsections. Instead, use bullet points, itemised lists, numbered lists, numbered examples, etc. instead (see Section 3.2 for more on these).

In what follows, we will use the word *component* as the general term for a section, subsection, or subsubsection. Thus, components are the building blocks of the document.

There are no hard and fast rules about ‘how long’ a component should be. It is more important that each numbered component contains a coherent content that is accurately summarised by its heading. However, in each document, component lengths at the same level should not be drastically different. For example, a document of 20 pages that contains 3 sections, one of 18 pages and the others with one page each, is an indication of poorly structured thinking.

At every level of decomposition there must always be AT LEAST TWO components. Thus, for example, a section can contain either no subsections or at least two subsections, but must *never* contain a solitary subsection. So, the following structure is NOT allowed:

1. Part One
2. Part Two
 2. 1 Part TwoPointOne
3. Part Three

Here Section 2.1 is called a ‘hanging’ subsection. There must never be hanging components. A hanging component is the firmest proof possible of a badly structured and poorly thought out document.

However, the following is OK:

1. Part One
2. Part Two
 - 2.1 Part TwoPointOne
 - 2.2 Part TwoPointTwo
3. Part Three

So it is acceptable to have some sections without any subsections.

5.4 The crucial role of ‘introductions’ and summaries

The following rules explain the nature of ‘introductions’ at different levels of decomposition:

- The first section of any report should be an introduction and overview of the entire report. It should end by giving a review of the subsequent sections. Look at Section 1 of this report for an example.
- Where a section is broken into subsections, the text immediately before the first subsection should be an introduction and overview of the entire section. It should end by giving a review of the subsequent subsections. Look at Section 3 of this report for an example. Note that Section 2 is not an example because it has no subsections.
- Where a subsection is broken into subsubsections, the text immediately before the first subsubsection should be an introduction and overview of the entire subsection. It should end by giving a review of the subsequent subsubsections.

In other words, at each level of decomposition, preceding the first main component at that level, there should be an introduction and overview of the set of components at that level. This introductory text should say what is contained in each of the components. Thus:

1. Section One (Introduction)

This is the introduction to the entire report. This report is about blah blah blah.

This report contains two main sections. Section 2 covers Section 3 covers

2. First main section

Since this section is broken into two subsections, the text here should just state what the purpose of this section is and what is covered in Section 2.1 and Section 2.2

2.1 Section TwoPointOne

The text for section 2.1 goes here

2.2 Section TwoPointTwo

Since this subsection is broken into two subsubsections, the text here should just state what the purpose of this subsection is and what is covered in Section 2.2.1 and Section 2.2.2

2.2.1 Section TwoPointTwoPointOne

The text for section 2.2.1 goes here

2.2.2 Section TwoPointTwoPointTwo

The text for section 2.2.2 goes here

Section Three

The text for section 3 goes here. No need for introduction as it has no subsections.

Where a section has more than one subsection it is also useful to include a summary at the end that reminds readers of the main points. In other words, structure each main section as follows:

1. Tell readers what you are going to tell them.
2. Tell them it.
3. Tell them what you have told them.

The same is true at the top level, because the first section of the report is the introduction to the whole report and the final section is the report summary.

5.5 Figures and tables

It is good to include figures and tables in your document because they break up the text and make it more readable. When using figures and tables you should stick to the following rules:

- Every figure and table in your document should be numbered and labelled, as in Figure 1 (Microsoft Word has very good features for handling numbering automatically – you should learn these.)



Figure 1: A very fine footballer

- Every reference to a figure or table should use the number of the figure or table. Thus, never write something like “the figure above shows a footballer”, but write “Figure 1 shows a footballer”. Spatial references to figures without numbering are nearly always ambiguous. Moreover, when you reformat your document you may find that the figure that was once ‘above’ actually appears on the top of the next page.
- Every figure or table that appears in a technical document must be cited at some point in the document (this is a consistency requirement).

5.6 A structure for student project reports

The following is an indication of the kind of structure you should use in the write-up of a computer science student project. Non-computer science students can ignore all but the main structure. In this example, I will assume the project is about building a web-based system for selecting mobile phone tariffs.

- *Abstract* (see Section 6) - less than one page
- *Table of Contents*
- Chapter 1. *Introduction* (see Section 5.4)
- Chapter 2. *Background/motivation*. Should set out the context for the work - why the chosen topic is important/interesting, and the main aim. In the example, this would address the issues of why people are interested in selecting mobile phone tariffs, and why a web-based system for this would be useful. This chapter should also provide an overview of the state-of-the-art of the application domain. In the example, this would mean writing up what you find about a) mobile phone tariffs, and b) existing systems for helping people select such tariffs. This should enable you to conclude that what you are proposing offers something new and/or different from previous work.
- Chapter 3. *Research*. This chapter should describe your own research (with full references) into the technical issues required to help you complete your project. In the example, there are actually two topics you would need to investigate: a)

algorithms that could help with tariff selection; and b) technologies and languages needed to create a web interface for your tariff selection solution. Depending on the amount of material you need to cover, you may wish to separate these into two chapters rather than two sections.

- Chapter 4. *Requirements*. This chapter should describe the requirements for the system you have built, together with how you captured the requirements. Normally you should include a high-level use case diagram and a description of the key use cases (typically two or three). For example, one use case might involve an end-user entering personalised data, ending with the system producing a recommendation. Another use case might involve a system administrator updating the data on tariffs in the system.
- Chapter 5. *Design*. This chapter should describe the high-level design of the system, preferably using one or more class diagrams.
- Chapter 6. *Implementation*. This chapter should provide an overview of the implementation, providing information about low-level design decisions not covered in the previous chapter. You should include screen shots. You should not include the full source code, but you should include code fragments that illustrate key points or algorithms in your implementation.
- Chapter 7. *Testing*. Describe your test plans, and how you carried them out. At the very least, you should explain how you tested against the use cases.
- Chapter 8. *Conclusions and recommendations*. Include the personal stuff (what you learned, what was good/bad, what worked/didn't, what you would do differently next time etc.), and recommendations relevant to the application.
- *References*. (see Section 8) -
- *Appendices* (Log of meeting, work plan, detailed class diagrams etc.).

5.7 Summary and checklist for when you finish writing

You should apply the following checklist before you give even an early draft of your document to a reviewer:

- Check that the structure conforms to all the rules described above.
- Read it through carefully, trying to put yourself in the shoes of your potential readers.
- Run the document through a spelling checker.
- Make sure you generate an up-to-date table of contents and references to figure and table numbers (selecting all the text, right-clicking with the mouse and pressing 'Update Field' in MS Word should do all of this for you).

6. Abstracts and executive summaries

There are two types of abstracts: *descriptive* and *informative*. A simple example of the difference is:

Descriptive

This report describes the advantages and disadvantages of each of the options available for dealing with the problem of increased air passenger traffic to Newtown, and provides a recommendation for a way forward.

Informative

This report describes the four options available for dealing with the problem of increased air passenger traffic to Newtown. The options are

1. Build a new runway at the existing airport
2. Build a new airport in Newtown West
3. Build a new airport 30 miles north
4. Do nothing

The first three options will all provide a short-term boost to the local employment market, while options 2 and 3 will provide long-term economic benefits. Option 1 is relatively cheap, but will only provide a short-term solution. Option 2 is expensive and unpopular with local Newtown residents. Option 3 is more popular, but just as expensive as option 2. However, there is a possibility of a higher government subsidy for option 3. Option 4 is likely to be ruled out after the result of the next local elections. We recommend option 3.

A descriptive abstract says what you do in the report without providing any of the information or results. An informative abstract (also called an *executive summary*) says what the report contains, including summarising the main results.

The descriptive abstract actually tells the reader *nothing* about the study. This writer is challenging the reader to read the entire report in order to find the basic results. The informative abstract, on the other hand, tells us all the key information about the study without including anything superfluous. Even if we do not have time to read the report (and most readers never get further than the abstract), it tells us what we really need to know.

You should always write informative abstracts rather than descriptive abstracts. Since informative abstracts are generally longer, this recommendation may come as a surprise to you. Elsewhere in this document, I have emphasised the need to write as few words as possible. The difference here is that descriptive abstracts provide no sensible information at all (beyond what you might find in the document title and table of contents). Hence, they are a complete waste of time and space. They are not an alternative to an informative abstract.

As a further, more comprehensive example, compare the following two abstracts describing the same case study:

Version A (descriptive)

This report describes a major case study to evaluate the effectiveness of using a formal method during software development. We describe the background of the method used and discuss the claims made in favour of these kinds of methods. We describe the experimental set-up, and the particular software under investigation. We present a range

of results indicating the circumstances under which formal methods may be effective. We explain the measurements that were used, along with the rationale for using them. We compare the results of the measurements at different life-cycle phases. We consider the different uses of the system. Finally, we present a number of strong recommendations.

Version B (informative)

VDM is one of the best-known formal methods used in software development. We describe a case study to evaluate whether higher quality code results from the use of VDM.

The case study involved an air traffic control system developed over three years. Some of the modules in the system were developed using VDM (160 modules making approximately 400 KLOC), while the rest of the modules (300 making approximately 700 KLOC) were developed informally.

We found that, prior to release, the fault density of formally developed modules was not significantly different from the informally developed modules (4 faults per KLOC being typical). However, the fault density in the 6 months post-release was significantly lower for formally developed modules (on average 0.6 faults per KLOC compared to 1.4 faults per KLOC). More faults were found during the early development phases in the formally developed modules. This favourable evidence, to support formal methods, is countered by the following observations:

1. The formally developed modules generally took 25% longer to complete than similar sized informal modules.
2. The formally developed modules were those concerned with the critical functions and were developed by more experienced and better qualified staff with a strong mathematical background.
3. The non-formally developed modules included all of the interface code so faults discovered in the first 6 months post-release were inevitably more likely to be in this part of the system.

Despite these reservations, we believe that the post release fault-density for the formally developed modules was very low. We therefore recommend that companies should consider using formal methods such as VDM for the most critical components, providing that they have well trained staff with a good mathematical background.

As in the previous example, Version A actually tells the reader *nothing* about the case study, whereas Version B tells us all the key information. Version B even makes us more likely to read the paper because it will identify and target key readers.

Since informative abstracts are so obviously superior to descriptive ones, why do the majority of scientific writers still insist on providing descriptive abstracts that infuriate us and insult our intelligence? Normally, the reason is laziness, although in some cases it may be because the author has nothing to say. Descriptive abstracts are often written *before* the work has even been carried out. In other words, the abstract is merely a plan for the author. Plans are fine and necessary in order to complete a piece of work; but if you were delivering any product, you would not use your original project plan as a replacement for the product description. So, never use a descriptive abstract.

7. Writing that includes mathematics

This section provides three of the most important rules to follow when your writing includes mathematical symbols and formulas. If you follow these rules, your report will be easier to read and understand.

Rule 1: All variables should be in italics to distinguish them from normal text:

Incorrect: The value of a increases when a is less than 100.

Correct: The value of a increases when a is less than 100.

Rule 2: When including equations in your work, these should be written on a separate line, and preferably labelled. The dangers of not doing so are that:

- The equation may end up stretching onto the next line;
- Readers may find it difficult to understand where the text is separated from the equation;
- It is generally much harder to follow.

Here is an example:

Incorrect:

The value of x can be computed as $x = 1/y + f(z)$. In this equation the expression $f(z)$ represents a particular function of z .

Correct

The value of x can be computed as:

$$x = 1/y + f(z) \quad \text{Equation (1)}$$

In Equation (1) the expression $f(z)$ represents a particular function of z .

The only exceptions to rule 2 are when the equation involves just two variables separated by an operator, such as $x=y$ or $x>2y$. In these cases, you do not need to leave a space between the symbols, so there is no chance the equation will run over the line.

Rule 3: Never start a sentence with a mathematical symbol of any kind, since this can create genuine ambiguity as well as just being hard to read. For example:

Incorrect: We have computed the value of x in terms of y and z . z is, in turn, expressed as a function of another variable.

Correct: We have computed the value of x in terms of y and z . The variable z is, in turn, expressed as a function of another variable.

8. Adding a references section

References should appear in a separate section at the end of a report. The easiest and most efficient way to do references is by numbering. So, for example, we have already seen some text taken from [1], while books [2,3,4] are those that I recommend as further reading. Have a look at the *references* section of this guide to see how to lay them out. Note that I have used an enumerated list with the numbers enclosed in square brackets (this is one of the pre-defined numbering formats in MS Word).

The massive benefit of using an enumerated list is that you can then use Word's cross-referencing functionality to refer to a particular reference by its number (use the "insert → cross reference → paragraph number option). If you add or change references, the numbering gets automatically updated when you apply the update command.

9. Summary and conclusions

No matter how poor you think your writing skills are, you really can learn how to improve them. Good technical writing is about using plain English. This is much easier than the writing style taught to many of you at school. You do not have to know and use long words and complicated phrases. You do not have to make your writing more 'interesting' by thinking of different ways to describe the same thing. In fact, the simpler and shorter you make things, the more likely you are to produce technical reports that get results.

This document has provided a number of easy-to-use guidelines to help you improve the reports you write. The crucial points are:

- Have a clear aim in mind before you start writing, and make sure that you gear everything you write towards that aim alone.
- Keep things as simple as possible by using language that is clear and familiar.
- Keep sentences and paragraphs short.
- Avoid long, pompous words and phrases when there is a short simple alternative (especially avoid the words: utilise, facilitate, endeavour, necessitate, render).
- Avoid unnecessary words, clichés and legal words.
- Avoid repetition.
- Use active rather than passive style.
- Do not turn verbs into nouns.
- Use personal rather than impersonal style.
- Always refer to the same 'thing' in exactly the same way.
- Make sure all reports conform to the basic structure described in Section 5 (title page with appropriate details, page numbers, appropriate section numbering, and introductions and summaries where appropriate).
- Use examples and analogies before introducing abstract concepts.
- Use a dictionary, and make sure you learn the words that are commonly misspelt or misused.
- Write informative (rather than descriptive) abstracts.
- If your writing includes mathematical symbols and formulas, follow the rules in Section 7 about how to display them.

Finally, once you have checked that your report conforms to the principles described here, ask a friend whom you trust to read it through before you submit it. Act on their recommendations, because they are likely to find the same problems that your intended readers will.

10. Acknowledgements

I am indebted to Ros Herman for setting me on the path to more effective writing. Many specific improvements have arisen directly from the numerous readers who, over the years, have found this guide on the web and pointed out errors (that I hope are all now fixed). Less directly, the guide has benefited from colleagues as well as scientific writers whom I have never met; on the one hand, I have been able to learn from, and incorporate, the style of the best of these writers, while on the other hand I have learnt what to avoid from the style of the worst of these writers. Sadly, even most of the leading academics consistently provide more examples of exceptionally bad writing than exceptionally good.

References

- [1] Jay R, 'How to Write proposals & reports that get results', Pearson Education Ltd, London, 2000
- [2] Kirkman J, 'Good style; writing for science and technology', E & FN Spon, London 1992
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- [4] Turk C, and Kirkman J, 'Effective writing: improving scientific, technical and business communication', E & FN Spon, London 1989