Division of Nuclear Engineering

Guidelines for Writing a Scientific Report

Prepared by:
Dmitry Grishchenko, Ignas Mickus
dmitrygr@kth.se, mickus@kth.se

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1 Introduction

Scientific writing is a difficult and time-consuming task. It is a skill that relies not only on the ability to clearly and concisely formulate one's thoughts but also on the clarity of the thinking process. The style, format and structure of scientific writing differs from those we encounter in social sciences and social communication, such as newspapers, books or e-mails, making it difficult to master [1]. However, mastering scientific writing or, taken broadly, scientific communication would probably pay-off more than any other academic skill you have or will develop [2]. The quality of your MSc, PhD and further career will depend on it, be it in or out of the academia.

This handout provides guidelines for writing scientific reports for students and young researchers. Therefore, the handout combines recommendations for reporting both authentic scientific research and lab practice.

This report addresses four major aspects of scientific writing: approach to writing, structure, formatting, and drafting; the reader will find those in Chapters 2, 3, 4, and 5, respectively. Chapter 2 provides an approach to writing a scientific report that should help make writing more efficient and goal oriented; Chapter 3 outlines the structure of a scientific report and indicates what must be written in each section. Chapter 4 discusses the details of the proper format, such as headers, captions, cross-referencing etc. Chapter 5 gives important recommendations on writing style, outlines the common writing mistakes, and provides the best practices for illustration. The contents here are partly compiled from a number of open sources. At the end of the document, you will find recommendations for further reading and references.

2 General approach to writing a scientific report

Below we outline a general approach to make the process of the scientific writing efficient and structured. Some deviations may occur depending on the progress of your work, type of scientific communication you are working on, and your personal habits. One can follow it when preparing a scientific paper, presentation or a report.

Formulate goals and tasks

In most cases, your goals and tasks are defined well before you start reporting on your work. However, research work is not a straightforward process and some alternations often occur. **Goals** are what you aim to achieve. **Tasks** are how you plan to achieve your goals.

As a student writing a lab report, your goal is to demonstrate that you have mastered the subject at hand. However, you need to think of your lab report as being larger than just a classroom assignment. Formulate your goals and tasks in more scientific perspective. Keep in mind that a lot of people might be reading your work - your peers, researchers from adjacent fields - and they will have two primary aims [7]:

- Understand your scientific results and statements.
- Verify that your results are established using a valid scientific procedure.

Therefore, one of your tasks as a student is to fulfil their aspirations.

Prepare statements

Write down in a bullet-like form the main statements (scientific conclusions) of your work. Defining your statements will enable you to focus your writing only on the information required to establish your statements. Make sure the statements correlate with your original goals and tasks; if not, review the latter.

Do not mix statements with results. Results are your scientific evidence, i.e. data you measure in an experiment, collect in a survey or compute; statements are what you conclude based on your results, i.e. what you have learned and what you want the reader to "take away". There are some cases when results are your statements, e.g. measurement and reporting of material properties.

Select evidence

Select a minimum of data that is required to support your statements. This will benefit the clarity of your presentation and importantly save you from writing sections of text that are unnecessary and you may have to remove later. At this step, you want to identify the statements that do not have sufficient supporting evidence and, therefore, shall be reviewed.

Reflect on your audience

The level of technicality and writing style should vary depending on the intended audience of your report. Make sure you adapt your writing accordingly. As a student reporting on a project, you are expected to demonstrate a depth of knowledge, understanding, and ability to master a specific set of skills. Being detailed will in most cases serve you well.

Prepare a template

A lot of time can be wasted if you start writing using the wrong formatting. Make sure you get it right before proceeding.

Prepare an outline

Write down an outline (contents) of your scientific communication. For every section summarize main subjects you want to describe; keep the subjects in the order they will be presented. Whenever you have doubts whether something should or should not be included, look at your statements and goals, the topic at hand must serve one of those.

Never bluntly describe your work in "historic order". The learning curve is rarely straightforward and is often entangled in mistakes. Instead, present your work in the order most favourable for understating.

Never omit information that may indicate a potential error in your results or be a source of unaccounted uncertainty. This will save you from embarrassment when someone else points it out and can be used as a motivation for improvement in the outlook section.

Start writing

Start the detailed writing with the section you feel most comfortable. In many cases, it is the description of methods and experimental procedure. This can be followed by preparation of all or almost all figures and tables for the results and discussion section. Remember that writing a literature review is time-consuming, so do not postpone it.

Review your work

Reviewing your work is an iterative process in which you want to involve your colleagues or classmates. Be open to criticism, otherwise, you are just impeding your progress.

Verify whether the content of individual sections follows formal requirements. Make sure there are no contradictory statements. Check for coherence between the Abstract, the Introduction and the Conclusion sections. Correct grammar and punctuation errors, improper wording. A helpful way to review your work is to read it backwards sentence by sentence. Taking sentences out of the context will help to identify those that lack clarity or have unintended meaning.

3 Structure

The organizational structure used to report experimental research in scientific disciplines commonly uses the IMRAD format: **I**ntroduction, **M**ethods, **R**esults, **A**nd **D**iscussion; in addition to that the content of a report commonly includes an Abstract, Conclusions, Acknowledgements, References and Appendix. Although the main headings are standard, details may vary.

3.1 Title

The title should describe the report's content clearly and precisely so that readers can decide whether to read the report. Make sure the title has key terms for indexing, helping a reader to find your work using online search engines [3, 4]. Key terms should (preferably) come early in the title.

A title should not (i) include wasteful words such as "studies on," "an investigation of"; (ii) use abbreviations, jargon, clichés, buzzwords, long and unnecessarily complicated terms; (iii) use casual language; (iv) be conclusive (state findings) or ambiguous.

3.2 Keywords

Keywords are a tool used by search engines to find manuscripts. Properly selected keywords make it easier for a reader to find your work. Keywords must represent the content of your manuscript and be specific to your field and sub-field. Keywords should complement, not repeat, those in the title. Examples of poor keywords: molecule, optics, computers.

3.3 Abstract or executive summary

The abstract should present the purpose of the paper/report, general methods, a summary of the most important results, and major conclusions. The abstract should be self-explanatory, i.e. intended for a reader who has not studied the paper yet. The abstract is usually written last.

An easy way to write an abstract is to extract the most important points from each section of the paper/report and then use those points to construct a narrative describing your study. Do not include any information that is not contained in the body of the paper/report. Do not include references to figures, tables or sources.

The same information is expected to be in the executive summary. The difference between an abstract and an executive summary is in the purpose. An abstract is intended to motivate reading of the report/paper and for that reason rarely exceeds a page of text. An executive summary is written for those who are not intended or have no time to read the report. Therefore, an executive summary may take up to 5-10% of the size of the original report and in some cases be issued as a separate document.

3.4 Introduction

A reader will expect to find the following information in the Introduction [5, 7]:

1. Literature review;
2. Goals and task (purpose);
3. Hypothesis and the reasons you believe the hypothesis is viable.

In the following, we will discuss each item and provide examples.

Literature review

For a researcher the goals of the literature review are:

- To demonstrate the awareness of previous work on the subject;
- To permit a reader to evaluate the study's pertinence to their own work;
- To identify the gaps in knowledge (establish motivation for the goals);
- To demonstrate that the identified gaps are important for the scientific community, the industry or the public.

As a student writing a lab report your goal is less complex:

- Demonstrate that you understand the context of the experiment or study you have completed.

Writing a literature review pertains the following:

- Be selective, not exhaustive, in choosing studies to cite and amount of detail to include.
- The studies you cite should be strongly related to your research question.
- Move from general to specific.
- Never provide personal characteristics (such as excellent, insightful, good) to cited research.

Goals and tasks

Make sure you can tell apart your research goals from your hypothesis. In professional setting, the goals or purpose of your work deal with what you want to achieve; while hypotheses are specific statements, you want to verify using your methods.

The goal of your work can be to assess the risks of radioactive product release in case of a severe accident in a nuclear power plant, while your statements can be related to the effectiveness of the adopted mitigation strategy for a set of plant damage states. As a student you may not have a wide-ranging research goal; in most cases, your goal will be to learn more about a specific scientific principle.

State your goal as clearly as possible, and use the same formulation throughout the paper/report. Do not be afraid of appearing repetitive. It shows the reader that you are consistent, and using the same terms throughout will avoid a lot of confusion [6].

Tasks define a way to achieve your goal. It is an outcome of analytical exercise that finds a solution to a general and complex problem by splitting it into a set of feasible tasks. Tasks may include the development of an analytical or experimental database, construction of a model, design of an experiment etc. In the lab report, your tasks may include a review of relevant literature, specific experimental tasks, analysis of the data etc.

Remember that poorly formulated goals and tasks will have a very negative impact on your work as it suggests that you are not clear about "what you want to achieve" and "how you plan to do it".

An example of goals and tasks:

- Goal: validation of a numerical model.
- Tasks:
  - Design and manufacture an experimental setup;

- Design an experimental test matrix;
- Perform experiments;
- Compare experiment vs model.

Hypothesis

Hypotheses are a prelude to your statements, i.e. a set of scientific questions you are intended to answer in your study. Just like statements should be written down before writing a report, hypotheses should be stated before conducting an experiment or a study.

Remember, that your hypothesis should not be drawn from thin air. You should provide justification or motivation for your statements. Providing such motivation, you are explaining what led you to believe that your "guess" might be supported by an adequate experiment [7].

An example of a hypothesis [7]:

"It was hypothesized that as the temperature of a solvent increases, the rate at which a solute will dissolve in that solvent increases."

Example of an introduction

Consider the following example of an introduction, which addresses the points discussed above.

"The purpose of the experiment was to test conventional ideas about solubility in the laboratory [purpose] . . . According to Whitecoat and Labrat (1999), at higher temperatures, the molecules of solvents move more quickly . . . We know from the class lecture that molecules moving at higher rates of speed collide with one another more often and thus break down more easily [background material/motivation] . . . Thus, it was hypothesized that as the temperature of a solvent increases, the rate at which a solute will dissolve in that solvent increases [hypothesis]" [7].

3.5 Methods

Pieces of evidence are the basis for your statements and conclusions; methods are the source of your evidence. A proper description of the methods used to establish your evidence is the cornerstone of your research. Not adequate, vaguely or incompletely described methods will jeopardise the confidence in your results and, consequently, in your whole work.

Describe the applied methods in enough detail that a reader with the same resources at his/her disposal could reproduce your experiment or calculation, but stay relevant. For example, it is rarely important what software you have used to record your data in the experiment. However, if the experimental procedure is connected to a control command logic of the DAS (Data Acquisition System), then describing the DAS might be necessary.

If you are a researcher, describe the established methods (such as SEM (Scanning Electron Microscopy), MRI (Magnetic Resonance Imaging), DTA (Differential Thermal Analysis) etc.) briefly, and simply cite a reference. If you are a student, devote a section in the Appendix where the readers can find more details.

Make sure you provide sufficient rationale for your procedure: a researcher aims to justify his/her approach against potential critics; a student wants to demonstrate that he/she understands well the reasons for performing the experiment in a specific order.

Use subheadings to separate different methodologies, for example, experimental from analytical. Order procedures chronologically or by type of procedure (sub-headed) and chronologically within the type. Use past tense to describe what you did in the experiment: you are not writing how to do an experiment (it is not a recipe) but how you conducted it. You are free to choose between passive or active voice; however, prefer using active voice to the largest extent possible, as this improves the clarity of your text.

Indicate potential sources of experimental error. You will need it to for uncertainty analysis in the Results chapter.

3.6 Results

In this section you are reporting facts you have established using your methods; nothing that can be disputed should appear here. However, you may point out trends that emerge when you present the data.

You must describe a result for every method that was outlined in the Methods section. To make the paper/report easier to follow and read, it is good practice to present the results in the same order as the methods [6].

Present your results with proper units, uncertainty intervals and a meaningful amount of significant digits. Use where appropriate tables and figures. Refer to Sections 4.8 and 5.8 for details.

As in the Methods section you want to refer to your results in the past tense. The reason is that you do not know if your observation will always hold.

3.7 Discussion

The Discussion section is where you interpret and explain the significance of your results. It contains several parts roughly moving from specific (i.e., related to your experiment only) to general (how your findings fit in the larger scientific community). In this section, you will need to:

- Explain whether the data support your hypothesis;
- Acknowledge any anomalous data or deviations from what you expected;
- Derive conclusions, based on your findings, about the process you are studying;
- Relate your findings to earlier work in the same area (if you can);
- Explore the theoretical and/or practical implications of your findings.

Let us look at some dos and don'ts for each of these objectives.

Explain whether the data support your hypothesis

This statement is usually a good way to begin the Discussion section since you can not effectively speak about the larger scientific value of your study until you have figured out the particulars of this experiment. You might begin this part of the Discussion by explicitly stating the relationships or correlations your data indicate between the independent and dependent variables. Then you can show more clearly why you believe your hypothesis was or was not supported.

Also, recognize that saying whether the data supported your hypothesis or not involves making a claim to be defended. As such, you need to show the readers that this claim is warranted by the evidence. Make sure that you are very explicit about the relationship between the evidence and the conclusions you draw from it.

Note: Students tend to view labs as practical tests of undeniable scientific truths. As a result, you may be tempted to say that the hypothesis was "proved" or "disproved" or that it was "correct" or "incorrect." These terms, however, reflect a degree of certainty that you as a scientist are not supposed to have. Remember, you are relying on a procedure that lasts only a few hours and has perhaps only a few trials; this severely compromises your ability to be sure about the "truth" you see. Words like "supported," "indicated," and "suggested" are more acceptable ways to evaluate your hypothesis.

Acknowledge any anomalous data or deviations from what you expected

For obvious reasons, your readers will doubt your authority if you (deliberately or inadvertently) overlook a key piece of data that does not square with your perspective on what occurred. In a more philosophical sense, once you have ignored evidence that contradicts your claims, you have departed from the scientific method. The urge to "tidy up" the experiment is often strong, but if you give in to it you are no longer performing good science.

Sometimes after you have performed a study or experiment, you realize that some part of the methods you used to test your hypothesis was flawed. In that case, it is OK to suggest that if you had the chance to conduct your test again, you might change the experimental design or procedure. The key to making this approach work, though, is to be very precise about the weakness in your experiment, why and how you think that weakness might have affected your data, and how you would alter your protocol to eliminate or limit the effects of that weakness.

Often, inexperienced researchers and writers feel the need to account for "wrong" data (remember, there is no such animal), and so they speculate about what might have screwed things up. These speculations include such factors as the unusually hot temperature in the room or the possibility that their lab partners read the meters wrong, or the potentially defective equipment. These explanations are what scientists call "cop-outs," or "lame"; do not indicate that the experiment had a weakness unless you are fairly certain that a) it really occurred and b) you can explain reasonably well how that weakness affected your results.

Derive conclusions, based on your findings, about the process you are studying

If, for example, your hypothesis dealt with the changes in solubility at different temperatures, then try to figure out what you can rationally say about the process of solubility more generally. If you are doing student lab, chances are that the lab will connect in some way to the material you have been covering either in lectures or in your reading, so you might choose to return to these resources as a way to help you think clearly about the process as a whole.

Remember, do not write that you experimental results "confirm" the theory, be more subtle about your conclusions use such words as "agree," "suggest," "indicate," etc.

Relate your findings to previous work in the field (if possible)

A reader can not fully understand the value of the research unless he/she gets some sense of the context that provoked and nourished it. You have to outline what is (potentially)new about your research and how it benefits the wider body of scientific knowledge. On a more pragmatic level, especially for students, connecting your lab work to previous research will demonstrate to the teachers that you see the big picture. You have an opportunity, in the Discussion section, to distinguish yourself from the

students in your class who are not thinking beyond the barest facts of the study. Capitalize on this opportunity by putting your own work in context.

Remember, it pays to be diplomatic when criticizing the work of others. Instead of pointing out weaknesses in other people's work, reformulate so as to present the strong points of your own work - the implication will be obvious, without you having to explicitly criticize your peers' publications. For example, instead of asserting that "Smith's study was underpowered," it is helpful to use a softer tone, such as "Smith's study may have been underpowered," or better yet, "Our study had sufficient statistical power to detect..."

If you are just beginning to work in the natural sciences, most likely the work you will be doing has already been performed and re-performed to a satisfactory degree. Hence, you could probably point to a similar experiment or study and compare/contrast your results and conclusions. More advanced work may deal with an issue that is somewhat less "resolved," and so previous research may take the form of an ongoing debate, and you can use your own work to weigh in on that debate.

Explore the theoretical and/or practical implications of your findings

This information is often the best way to end your Discussion (and, for all intents and purposes, the report). In argumentative writing generally, you want to use your closing words to convey the main point of your writing. This main point can be primarily theoretical ("Now that you understand this information, you are in a better position to understand this larger issue") or primarily practical ("You can use this information to take such and such an action"). In either case, the concluding statements help the reader to comprehend the significance of your project and your decision to write about it.

Since a lab report is argumentative - after all, you are investigating a claim, and judging the legitimacy of that claim by generating and collecting evidence - it is often a good idea to end your report with the same technique for establishing your main point. If you want to go the theoretical route, you might talk about the consequences your study has for the field or phenomenon you are investigating. If you want to go the practical route, you could end by speculating about the operational, institutional, or commercial implications of your findings - in other words, answer the question, "What can this study help people to do?" In either case, you are going to make your readers' experience more satisfying, by helping them see why they spent their time learning what you had to teach them.

Note: It is not always convenient to separate the Results chapter from the Discussion. Sometimes the two chapters are merged and results are provided together with implications.

3.8 Conclusions

Conclusions include a short summary of the experience, learned statements and often an outlook (unless you have a separate section for that). Discuss in brief the limitations and uncertainty sources that were not included in the error estimation.

3.9 Acknowledgements

Acknowledgements should be brief, and should not include thanks to anonymous referees and editors. A person can be thanked for assistance, not "excellent" assistance, or for comments, not "insightful" comments. Make sure you use proper affiliations (Prof., Dr., Mr etc.) when referring to people. Acknowledgements can contain grant and contribution numbers. Below are some examples:

- I would like to express my very great appreciation to...
- I would like to offer my special thanks to...
- Advice given by ... has been a great help in...
- I wish to thank...
- I am particularly grateful for the assistance given by...
- I would also like to thank the staff of the...

3.10 References

The Reference section lists all the sources you have used in your report. It is your ethical and professional responsibility to document your work adequately and provide full transparency in identifying your sources. It is also imperative to cite the sources on which your hypotheses are based, to prove that they are in fact sound. The references support your work and place it in the context of other studies on the same topic, while at the same time providing guidance for readers who would like to engage in further reading on the topic. Many young researchers find it hard to judge when it is necessary to cite a reference. Basically, any idea or fact that emanates from another source (other than yourself) needs to be supported by a reference. However, universal truths or facts that are widely established do not need to be referenced. Be sure to reference as you write, it will be very difficult to do retrospectively.

3.11 Appendix

An appendix contains information that is supplementary and not strictly necessary to the main body of the document. An appendix may include a reference section for the reader, a summary of the raw data or extra details on the method behind the work.

You should order the content in the appendix based on when it appears in the text. This will make the appendix more reader-friendly and make it easier to access.

4 Formatting

4.1 Title

We recommend using the *title case* for the title. Do not use a full stop (period) at the end of a title. However, it is compulsory to use a question mark if the title is a question, or exclamation sign if the title implies one.

Examples of a title:

- Writing a Scientific Article: Easier than it Sounds?
- Steam Explosion in Nuclear Reactors

4.2 Abstract/Executive summary

The Abstract or Executive Summary is commonly the first section that appears in a report. Do not number the header.

4.3 Contents

Depending on the type of the document you are writing the Contents section can be preceded by different sections. In case of a scientific report, it is commonly an abstract or an executive summary.

Do not include "Contents" in the list of the contents.

4.4 List of figures

The List of Figures is commonly added after the Contents. Items in the list include figure caption (with the main title) and page number where the figure can be found. Most text editors can create the list of figures automatically. You do not need to provide a list of figures if you have fewer than 5 figures.

4.5 List of tables

The List of Tables is commonly added after the List of Figures. Items in the List of Tables include the table caption (with the main title) and the page number where the table can be found. Most text editors can create the list of tables automatically. You do not need to provide a List of Tables if you have fewer than 5 tables.

4.6 Headers

Use sentence case. Do not use a period at the end of a header. Header shall not exceed two lines of text. Use multilevel numbering in headers - it helps to structure the report and orients a reader. There is no need to start your header on a new page unless it falls at the end of a page.

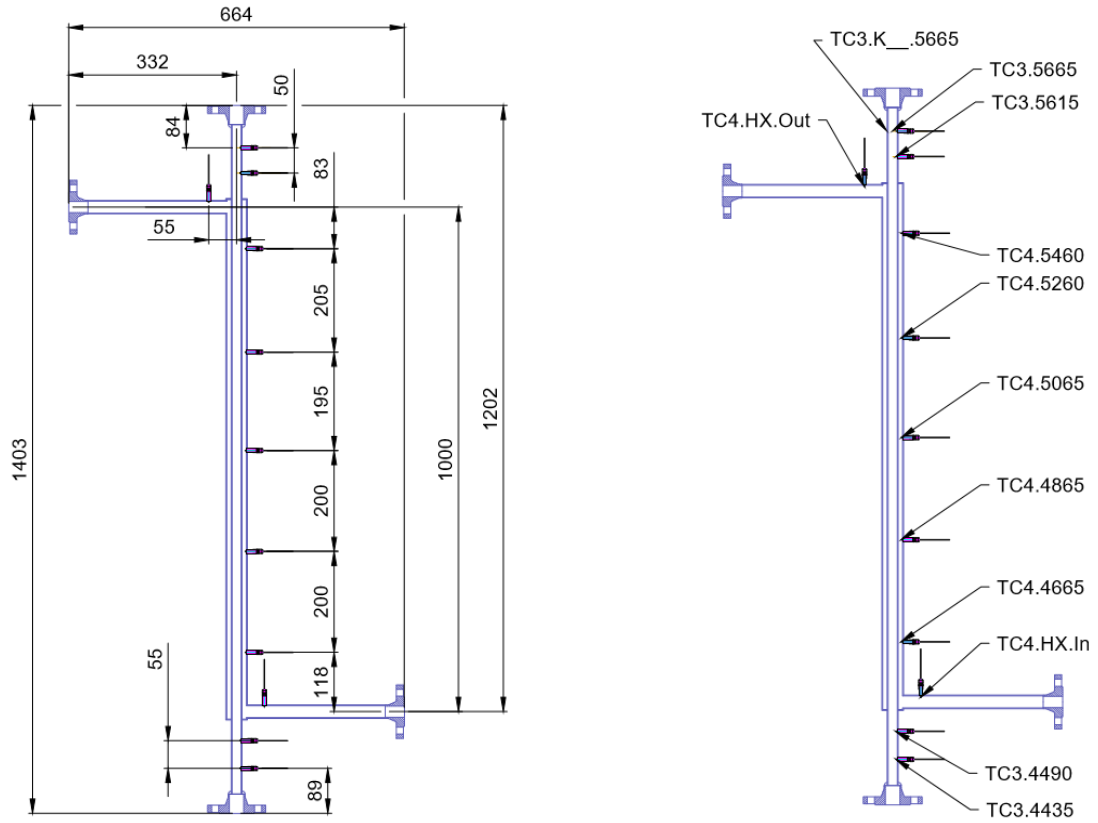
Example of a header:

- 2. Getting started: things to do before you write a word

4.7 Fonts and paragraphs

In most cases, you will get a template for your report or publication that will define necessary details regarding fonts, paragraphs, margins etc. If not, then consider the following:

- Times New Roman, 12 pts is the standard choice for academic documents. If you want to use something different consider Calibri, Courier or Constantia, but remember that readability is your main criteria. It can be beneficial to print a sample of you work as some fonts does not look as good on a paper as they do on the screen and vice versa.
- It is advisable to use different fonts for the headers and body text: this helps to visually isolated the headers. Do not go too fancy here, in most cases it is sufficient to increase the font size and/or make it bold.
- Make sure your paragraphs are separated from each other with an extra blank line. Do not type it in; instead, use the paragraph space option in your text editor.
- If writing in columns - justify your text; otherwise, align your text on the left or make it justified. In general, justified text looks cleaner.
- Do not use hyphenation to move a part of a word to the next line - it impairs reading: modern text editors adjust spacing between the words making hyphenation unnecessary.



(a) (b)

Figure 1: Tall-3D heat exchanger
(a geometry; b location of thermocouples)

4.8 Tables and figures

Caption and number each table/figure; use periods at the end of each caption. Table caption must be located above the table; caption to a figure is placed underneath the figure. Both captions are centred. The caption should be short but descriptive enough to communicate the contents of the table/figure.

Refer to each table or figure directly in the text, where appropriate:

- "Table 1 lists the rates of solubility for each substance" or
- "Solubility increased as the temperature of the solution increased (see Figure 1)."

Never use references similar to "In the figure above...". Text position may change with respect to the figure or you may have more than one figure "above".

If your figure uses inserts (subfigures), it is common to name each individual insert with a letter in alphabetical order. In such case, the caption must include in brackets all subcaptions (see Figure 1). Refer to the subfigure combining the figure caption and subcaption:

- "...as can be seen from Figure 5b ..."

If your figure or table is the same as or based on another author's, it is standard to include the words "Adapted from" or "After" followed by the author's name and a citation at the end of the caption.

Avoid inserting graphs linked to external content, this may slow down your text editor and lead to unexpected changes in the document. If you generated your graph in an external editor, export the graph into your document as a vector image to improve quality.

Table 1: Example of a table formatting

Parameter	Units	Test 1	Test 2
Density	kg/m^3	9500	9500
Temperature	°C	225	250
Heat capacity	J/kg·K	460	560
Latent heat	kJ/kg	250	420
Time	s	203	548

When formatting a table do not use vertical lines as part of the format for your tables. Vertical alignment of the elements is in general sufficient for visually ordering the elements. Use horizontal lines to divide the table into blocks (for example, see Table 1).

4.9 Equations

Equations in a scientific report should be visibly differentiated from the rest of the text [9]. Set the equation off from the text by inserting it as a new paragraph. Number each equation consecutively with equation numbers in parentheses and describe all (new) terms in the equation immediately after it; consider the following example.

The heat transfer coefficient for subcooled film boiling over a heated horizontal surface can be estimated using Eq. (1):

$$\alpha_{fb} = 0.62 \left[\frac{\lambda_s^3 \rho_s (\rho_w - \rho_s) H_{ws} g}{\Delta T \mu_s} \frac{1}{2\pi} \sqrt{\frac{g(\rho_w - \rho_s)}{\sigma_w}} \right]^{1/4}, \tag{1}$$

where g is the gravity acceleration, [m/s^2]; ρ_s, ρ_w are densities of steam and water respectively, [kg/m^3]; σ_w is water surface tension; $\Delta T = T_w - T_s$ is water subcooling, [K]; H_{ws} is enthalpy of water evaporation, [J/kg·K].

Notice that unit symbols are written in upright, while variables and quantity symbols are written in italic in the text [1].

If you reference the equation at the beginning of the sentence write "Equation (1) ...," otherwise, use a shortened version Eq. (1). Do not number an equation unless you reference it in the text.

4.10 References

There are two common styles for formatting references: Harvard and Vancouver. Harvard style uses (author name, year) format for citation, and items in the reference list appear in alphabetical order. In Vancouver style, you cite references numerically [#], and items in the reference list are numbered accordingly and follow the order they appear in the text.

Vancouver format is preferential for scientific writing: it is shorter and permits grouped citations, e.g. [5-10,13-15]. However, it does require an automatic indexing tool to create the reference list and keep it ordered. Harvard style is a lot easier to handle.

In order to format your references, it is recommended to use one of free (such as Mendeley) or commercial (such as EndNote) indexing tools in your text editor. In case you write the references yourself, follow the format suggested in the Table 2. See [11] for more details.

[1] You can find more equation style conventions following this link: `https://physics.nist.gov/cuu/Units/checklist.html`

Table 2: Format of references list

Resource	Structure of the reference
Journal article	Author's Last Name, Initials. (Publication Year). Title of article. Title of Periodical, volume #(issue #), pppp. doi:xx.xxxxxxxxxx Author's Last Name, Initials. (Publication Year). Title of article. Title of Periodical, volume #(issue #), pppp. Retrieved from http://...
Newspaper	Author's Last Name, Initials. (Publication Year, Month Day). Title of article. Name of Newspaper. Retrieved from http://...
Book	Author's Last Name, Initials. (Publication Year). Title of book. doi:xxxxxxx Author's Last Name, Initials. (Publication Year). Title of book. City, State: Publisher.
Chapter in edited book	Author's Last Name, Initials. (Publication Year). Article or chapter title. In Editor First Initial. Second Initial. Editor Last Name (Ed.), Book title (page range of chapter). Place of Publication: Publisher.
Web page with no author	Name of Organization. (Year). Title of web page. Retrieved from http://...
Web page with an author	Authors Last Name, Initials. (Publication Year, Month Day). Title of web page. Title of website. Retrieved from http://...
Web page with no author and organization	Title of webpage. (Publication year). Retrieved from http://...
Wikis	Term. (Year). In Title of Wiki. Retrieved [Date], from http://...

4.11 Appendix

The appendix should be titled on the top of the page; use the same font as for your chapter headings. If you have more than one appendix, order them by letter or number and be consistent about the ordering. For example, if you are using letters, make sure the appendices are titled "Appendix A," "Appendix B," etc. If you are using numbers, make sure the appendices are titled "Appendix 1," "Appendix 2," etc. If you have more than one appendix, make sure each appendix begins on a new page.

4.12 Emphasis

Do not use colours to emphasize different parts of the text. Avoid using multiple emphasizing techniques like bold fonts, italic fonts and underlining. Do not overuse emphasis, remember your goal is clarity.

5 Drafting

Scientific writing is structured to maximize content and clarity and minimize length. Instead of trying to impress the reader with an expert use of the English language, spend your time making your research materials simple, easy to read and to the point [8].

5.1 Numbers

Numbers can be written either as words (e.g., one hundred) or numerals (e.g., 100). The basic rule is to use words for numbers from zero through nine, and numbers from 10 onwards. This is true for both cardinal numbers (e.g., two, 11) and ordinal numbers (e.g., second, 11th). However, there are some exceptions [13]:

- Use numerals for numbers from zero to nine that are followed by a precise unit of measurement or grouped together with a number that is ≤ 10:
  - The samples measured 7 cm in diameter. ("cm" is a unit of measurement)
  - However, only 3 of the 12 were usable. ("3" is being grouped with "12")
  - But: These three samples were subjected to further testing.
- Use words for any number that is used to start a sentence, with the exception of years.
- Use words for common fractions and set expressions:
  - According to the survey, one-half of the employees are dissatisfied.
  - Understanding the Five Pillars of Islam is a critical first step.
  - The Fourth of July is traditionally marked by a firework display.
- Use a period to indicate a decimal point.
- Report numbers from quantitative research down to the measurement error; if measurement error is not defined, use the following recommendations:
  - Report most statistics to two decimal places (such as $M = 521.44$).
  - Report statistics that could never exceed 1.0 to three decimal places (such as $p \leq 0.001$).
  - Report percentages and degrees of freedom as whole numbers (such as 73%).
- Include spaces before and after $=$, $>$, and $<$.

Examples of using numbers [13]:

"At about the age of seven, the girl's height was 1.47 m. This placed her in the fifth percentile, although her weight placed her in the top 7% of her class. By the time she was 9 years old, she was taller than half of the boys in her year. Five years later, she was still ranked 15th."

"Thirteen thousand viewers watched the performance of Shakespeare's Twelfth Night from the park, while another 2,000 watched from the surrounding buildings and 1.2 million watched it on television. As 1 out of every 11 residents saw at least part of the play, this one event can definitely be considered a success."

5.2 Verbs

Verbs are for describing actions, states, or occurrences [12]. To give a clause its full strength and keep it short, do not bury the action, state, or occurrence in a noun (typically combined with a weak verb), as in "The catalyst produced a 3.0x increase in conversion rate." Instead, write "The catalyst increased the conversion rate three times." You may also see this as a way of shortening your sentence.

The examples below show how an action, state, or occurrence can be moved from a noun back to a verb:

- an examination of → examine
- a comparison of → compare
- be in agreement → agree
- perform an analysis of → analyse
- produce an improvement in → improve

Avoid dangling verb forms. Consider the following examples:

- To dissect its brain, the affected fly was mounted on a ...
- After ageing for 72 hours at 50 °C, we observed a shift in ...

Here, the first sentence implies that the affected fly dissected its own brain, and the second implies that the authors of the paper needed to age for 72 hours at 50 °C in order to observe the shift. To restore the intended meaning while keeping the infinitive to dissect or the participle ageing, change the subject of each sentence as appropriate:

- To dissect its brain, we mounted the affected fly on a ...
- After ageing for 72 hours at 50 °C, the samples exhibited a shift in ...

Alternatively, you can change or remove the infinitive or participle to restore the intended meaning:

- To have its brain dissected, the affected fly was mounted on a ...
- After the samples aged for 72 hours at 50 °C, we observed a shift in ...

5.3 Sentences

Constructing effective sentences requires practice. To construct sentences that reflect your ideas, focus these sentences appropriately. Express one idea per sentence. Use your current topic as the grammatical subject of your sentence. When writing a complex sentence (a sentence that includes several clauses), place the main idea in the main clause rather than a subordinate clause.

Then, work on conciseness: see whether you can replace long phrases with shorter ones or eliminate words without loss of clarity or accuracy.

Below is a list of recommendations adopted from [12]:

- Consider placing the main idea of the sentence in the main clause (marked in red) rather than in a subordinate one (marked in blue):
  - Instead of: Figure 5 shows that translocation time scales linearly with polymer length.
  - Consider: The translocation time scales linearly with polymer length (Figure 5).

- Never place the main idea of the sentence in the subordinate clause of the subordinate clause (marked in blue):
  - Instead of: The estimated mean free path in these systems was above 25 μm, which establishes that the samples studied were well within the quasi-ballistic regime.
  - Consider: With a mean three path estimated above 25 μm, the samples studied were well within the quasi-ballistic regime.
- A main clause with the structure "it is ... that" can often be replaced by a single adverb (or removed altogether):
  - It is clear that → Clearly,
  - It is evident that → Evidently,
  - It is remarkable that → Remarkably,
  - It is possible that → Possibly,
  - It is a surprise that → Surprisingly.
- If something is worth mentioning, you should certainly mention it, but there is no need to point out that it is worth doing so:
  - Instead of: It is worth mentioning that earth rotates around the sun.
  - Consider: Earth rotates around the sun.
- Consider splitting sentences that have 3 and more subordinate clauses:
  - Instead of: It is important to note that if autophagy is involved in the process of lysis, it will enable a complete mapping of these pathways because the mechanisms for the molecular regulation of autophagy are well described, which is not the case with lysis.
  - Consider: If autophagy is involved in the process of lysis, it will enable a complete mapping of these pathways. Indeed, the mechanisms for the molecular regulation of autophagy are well described, unlike those of lysis.
- When reporting your observations, focus on what happened rather than on the fact you observed it. Thus, avoid main clauses such as "it was observed that". In addition, express actions with verbs, not with nouns.

Avoid inflated phrases - they make writing more complicated than it actually is and makes reading difficult. Examples of inflated sentences that should be shortened are given in Table 3.

Table 3: Inflated phrases (adapted from [13])

Inflated phrase	Example	Concise alternative	Example
A majority of	A majority of respondents were single parents.	Most	Most respondents were single parents.
A sufficient amount/ number of	A sufficient number of cases were selected.	Enough	Enough cases were selected.
As a result of	The interview was cancelled as a result of illness.	Because of, due to	The interview was cancelled due to illness.
At all times	The laptop was kept in a locked office at all times.	Always	The laptop was always kept in a locked office.

Table 3: Inflated phrases (adapted from [13])

Inflated phrase	Example	Concise alternative	Example
At the present time, at this point in time	The IT sector is expanding at the present time.	Now, currently	The IT sector is currently expanding.
By means of	The surveys were distributed by means of email.	By	The surveys were distributed by email.
Draw attention to	Articles often draw attention to the most problematic cases.	Point out, point to	Articles often point to the most problematic cases.
Due to the fact that, in light of the fact that	This definition cannot be used due to the fact that it is too limiting.	Because	This definition cannot be used because it is too limiting.
For the purpose of	A spreadsheet was used for the purpose of recording the data.	For	A spreadsheet was used for recording the data.
For the reason that	Consultants were excluded for the reason that they are not regular staff.	Because	Consultants were excluded because they are not regular staff.
Have a tendency to	Economists have a tendency to favour policy reform.	Tend to	Economists tend to favour policy reform.
Have an impact on	Age appears to have an impact on confidence.	Affect	Age appears to affect confidence.
Have the ability to	The scale has the ability to measure to the microgram.	Be able to, can	The scale can measure to the microgram.
In comparison to	The data showed that CEOs earn more in comparison to CFOs.	Than	The results showed that CEOs earn more than CFOs.
In order to	More research is needed in order to fill this gap.	To	More research is needed to fill this gap.
In spite of the fact that, despite the fact that	In spite of the fact that the sample size was limited, ...	Although	Although the sample size was limited, ...
In the event that	In the event that a question was left blank, ...	If	If a question was left blank, ...
In the neighbourhood of	The factory produces in the neighbourhood of 5,000 cars a week.	About	The factory produces about 5,000 cars a week.
In the year YYYY	Sales peaked in the year 2001.	YYYY	Sales peaked in 2001.
Is of the opinion	Wang (2009) is of the opinion that the model must be expanded.	Thinks, believes	Wang (2009) believes that the model must be expanded.

Table 3: Inflated phrases (adapted from [13])

Inflated phrase	Example	Concise alternative	Example
Make a calculation of	We made a calculation of the average IQ.	Calculate	We calculated the average IQ.
Make decisions about	Marketers must make decisions about their target audience.	Decide on	Marketers must decide on their target audience.
On two occasions	The patients were tested on two occasions.	Twice	The patients were tested twice.
Small in size	The control group is relatively small in size.	Small	The control group is relatively small.
The people who are located in	The people who are located in rural areas had fewer symptoms.	The people in	The people in rural areas had fewer symptoms.
The reason why	The reason why the population decreased is unknown.	The reason	The reason the population decreased is unknown.
Until such time as	Smartphones will be used until such time as a new technology is developed.	Until	Smartphones will be used until a new technology is developed.
Whether or not	The goal was to identify whether or not gender made a difference.	Whether	The goal was to identify whether gender made a difference.

Another common mistake in writing is redundancies. It occurs when the same idea is expressed twice, i.e. when the meaning of one word is implied in another. Table 4 lists examples of redundant phrases that should be avoided.

Table 4: Redundant phrases (adapted from [13])

Redundant phrase	Improvement
Advance planning	Planning
Alternative choice	Alternative
Ask the question	Ask
Assemble together	Assemble
Basic fundamentals	Fundamentals
Biography/autobiography of her life	Biography/autobiography
Brief moment	Moment
Brief summary	Summary
Careful scrutiny	Scrutiny
Cash money	Cash

Table 4: Redundant phrases (adapted from [13])

Redundant phrase	Improvement
Classify into groups	Classify
Collaborate together	Collaborate
Combine together	Combine
Compete with each other	Compete
Completely filled	Filled
Cooperate together	Cooperate
Could possibly	Could
Crisis situation	Crisis
Current incumbent	Incumbent
Current trend	Trend
Depreciate in value	Depreciate
Different kinds	Kinds
Disappear from sight	Disappear
During the course of	During
Each and every	Each
Earlier in time	Earlier
Empty space	Space
Equal to each other	Equal
Estimated at about	Estimate at
Favourable approval	Approval
Fellow colleague	Colleague
Few in number	Few
Final conclusion	Conclusion
Final end	End
First and foremost	Foremost
First of all	First
Follow after	Follow
Foreign imports	Imports
Former graduate	Graduate
Free gift	Gift
Future plans	Plans
General public	Public
Grow in size	Grow

Table 4: Redundant phrases (adapted from [13])

Redundant phrase	Improvement
Had done previously	Had done
HIV virus	HIV
Input into	Input
Interdependent on each other	Interdependent
Introduced for the first time	Introduced
Joint collaboration	Collaboration
Knowledgeable experts	Experts
Later time	Later
Little baby	Baby
Live audience	Audience
May possibly	May
Meet together	Meet
Might possibly	Might
Mix together	Mix
Mutually interdependent	Interdependent
Mutual respect for each other	Mutual respect
New innovation	Innovation
New invention	Invention
None at all	None
Oral conversation	Conversation
Over exaggerate	Exaggerate
Passing fad	Fad
Past history	History
Past memories	Memories
Present time	Present
Previously listed above	Previously listed
Protest against	Protest
Recur again	Recur
Re-elect for another term	Re-elect
Regular routine	Routine
Reply back	Reply
Safe haven	Haven
Spell out in detail	Spell out

Table 4: Redundant phrases (adapted from [13])

Redundant phrase	Improvement
Splice together	Splice
Still persists	Persists
Sum total	Total
Surrounded on all sides	Surrounded
Tall in height	Tall
Two/2:00 pm in the afternoon	Two/2:00 pm
Two equal halves	Halves
True facts	Facts
Unexpected surprise	Surprise
Unintentional mistake	Mistake
Very unique	Unique
Visible to the eye	Visible
Warn in advance	Warn

Last but not least, avoid using unspecific expressions such as "at high temperature," "a lot longer," "much faster," "highly significant," etc. Besides the fact that they obscure the meaning, they may also confuse the reader: much faster for you may not be "much faster" for someone else. Whenever you can, be specific and indicate how much faster, longer or higher your parameter is.

5.4 Paragraphs

To facilitate reading, text is divided onto paragraphs. A paragraph is a section of text consisting of one or several sentences and dealing with a particular point or idea (subject). The subject of a paragraph must be stated in the first sentence. Make sure the first sentence is clear and possibly short; the aim is to inform a reader about the subject at hand, not to outline the content of the paragraph. In addition to the main idea expressed in the first sentence, a paragraph should describe evidence that support the main idea and analysis of the evidence. The last sentence of a paragraph is expected to either neatly tie together the content of the paragraph or introduce a linking thought to the next paragraph.

Sentences within a paragraph must be logically connected. To facilitate the logical connection, consider repeating the ending of the preceding sentence at the beginning of the next one. Notice colour marking in the previous paragraph. In addition, make use of Conjunctive Adverbs (see Section 5.7) and pronouns (see Section 5.6).

In scientific writing, clarity has a priority over language richness. Therefore, you should avoid unnecessary usage of synonyms: select and stick to proper terminology throughout the entire writing. If repetition of a noun becomes overwhelming, consider using a pronoun; if usage of a pronoun is ambiguous (see Section 5.6), try a synonym instead.

Make sure your paragraphs do not tax readers' short-term memory by obliging to remember long pieces of text before knowing what to do with them. In other words, keep together what goes together.

5.5 Usage of tenses

Improper use of tenses in your writing is just as harmful as the use of redundant and inflated sentences. It will especially annoy native speakers and professionals. For the common use of tense in academic writing follow these recommendations [12]:

- Past tense
  - Work done:
    - We collected blood samples from ...
    - Groves et al. determined the growth rate of ...
    - Consequently, astronomers decided to rename ...
  - Work reported:
    - Jankowsky reported a similar growth rate ...
    - In 2009, Chu published an alternative method to ...
    - Irarrázaval observed the opposite behaviour in ...
  - Observations:
    - The mice in Group A developed, on average, twice as much ...
    - The number of defects increased sharply ...
    - The conversion rate was close to 95% ...
  - Formulating aims and hypothesis:
    - We hypothesized that A is equal to B ...
    - We aimed to achieve A ...
- Present tense
  - General truths:
    - Microbes in the human gut have a profound influence on ...
    - The Reynolds number provides a measure of ...
    - Smoking increases the risk of coronary heart disease ...
  - Atemporal facts:
    - This paper presents the results of ...
    - Section 3.1 explains the difference between ...
    - Behbood's 1969 paper provides a framework for ...
- Present perfect
  - Describe something that has not happened yet:
    - It has not been yet determined if ...
  - Describe something that has started in unspecified time and is not completed yet:
    - Several researches have investigated the effect of drug A on this disease ...
- Future tense
  - Perspectives:
    - In a follow-up experiment, we will study the role of ...
    - The influence of temperature will be the object of future research ...

5.6 Pronouns

Usage of pronouns (it, this, which, who etc.) is intuitive and rarely can be a source of a grammatical error. However, pronouns, if used improperly, may severely impair the clarity of your writing. If the antecedent (the noun that the pronoun replaces) of the pronoun is unclear, then the sentence will be unclear as well. An ambiguous pronoun occurs when more than one possible antecedent exists. Consider the example in Table 5.

Table 5: Usage of pronouns

Instead of:	With her phone in one hand and her camera in the other, Mavis snapped photos with it as the parade passed.
Consider:	With her phone in one hand and her camera in the other, Mavis snapped photos with the camera as the parade passed.

5.7 Conjunctive adverbs

Conjunctive adverbs can be used at the start of a sentence to indicate result, concession, apposition, addition, time, contrast, summary, or reinforcement [10]:

- Result: therefore, consequently, of course
- Concession: nevertheless, yet, still, after all, of course
- Apposition: for example, for instance, that is, namely, in other words
- Addition: moreover, furthermore, also, in addition, likewise, further
- Time: meanwhile, in the meantime
- Contrast: however, instead, on the contrary, on the other hand, in contrast, rather
- Summary: thus, in conclusion, then
- Reinforcement: further, in particular, indeed, above all, in fact

Table 6: Conjunctive adverbs: punctuation

Instead of:	Dr. Wheeler is a grammar tyrant, thus, he requires correct punctuation.
Consider:	Dr. Wheeler is a grammar tyrant; thus, he requires correct punctuation.
	Dr. Wheeler is a grammar tyrant. Thus, he requires correct punctuation.

Conjunctive adverbs are often used wrongly to merge two sentences. If the two parts you are connecting can stand on their own as separate sentences, then you have probably misused the conjunctive adverb. If this is the case, you have a few options for fixing it. Usually, a semicolon is the best choice, but you may also use a period or a coordinating conjunction (see Table 6) [10].

Conjunctive adverbs can also function as simple adverbs. In such a situation, they merely modify a verb, adjective, or another adverb. When they behave this way, they do not need any special punctuation. They are simply functioning as adverbs. For example, consider these two sentences:

- She was accordingly quite interested in grammar.
- However ugly the gargoyle may be, I will go on a blind date with him.

Here, *accordingly* and *however* are simple adverbs. All *accordingly* does is modify the verb interested. All *however* does is modify the adjective ugly.

5.8 Tables and figures

If you are trying to decide between using a table and creating a figure to present your material, consider the following a rule of thumb. The strength of a table lies in its ability to supply large amounts of exact data, whereas the strength of a figure is its dramatic illustration of important trends within the experiment. If you feel that your readers will not get the full impact of the results you obtained just by looking at the numbers, then a figure might be appropriate [7]. If you use tables or figures, make sure that you do not present the same material in both the text and the tables/figures, to avoid redundancy.

Designing a graph, you may be tempted to signal the complexity of the information you gathered by trying to account for that complexity. But remember the purpose of your graph: to dramatize your results in a manner that is easy to see and grasp. Try not to make the reader stare at the graph for a half hour to find the important line among the mass of other lines. For maximum effectiveness, limit yourself to five lines per graph; if you have more data to demonstrate, use a set of graphs to account for it, rather than trying to cram it all into a single figure. Make each line in your graph easy to distinguish by attaching a symbol to them.

Plot the independent variable on the horizontal (x) axis and the dependent variable on the vertical (y) axis. Remember that the independent variable is the condition that you manipulated during the experiment and the dependent variable is the condition that you measured to see if it changed along with the independent variable. If the data you plot varies in several orders of magnitude, consider using log scales for axes.

Label each axis carefully, and be especially careful to include units of measure. You need to make sure that your readers understand perfectly well what your graph indicates.

Make your graph large enough so that everything is legible and clearly demarcated, but not so large that it either overwhelms the rest of the Results section or provides a far greater range than you need to illustrate your point. If, for example, you were measuring the counting rate up to 5 cm from the source, you do not need to construct a graph that accounts for 100 cm of distance. The lines in your graph should more or less fill the space created by the axes; if you see that your data is confined to the lower left portion of the graph, you should probably re-adjust your scale.

If you create a set of graphs, make them the same size and format, including all the verbal and visual codes (captions, symbols, scale, etc.). You want to be as consistent as possible in your illustrations so that your readers can easily make the comparisons you are trying to get them to see.

Designing a table, you may wonder whether to arrange similar data in a column or in a raw. The choice is up to you but readability and compactness of the table should be your criteria. Also, keep in mind that you can always add a row to a table while adding a column is limited by the page margins. Make sure to include units of measurement in the tables.

5.9 Abbreviations

Abbreviations, when few, is a useful tool to shorten your writing; however, if used excessively, it can make the reading of otherwise excellent text unbearable. Many of us experienced the process of an annoying flipping of pages in the search of the proper definition of an acronym. To make the best of abbreviations follow few rules:

- Introduce an abbreviation only if you intend to use it 3 or more times;
- Always use abbreviations for well-known terms (e.g. IQ, IBM, AIDS, UPS, FAQ);
- Consider listing used abbreviations and their definitions at the beginning of your document;
- Make sure an abbreviation you introduce does not carry an unintended meaning, e.g. Wisconsin Tourism Foundation (WTF);
- Make sure you define an abbreviation before you use it.

When writing conclusions, you may want to reintroduce abbreviations or avoid using them. This is intended to make the reading of the conclusions independent of the main body of the text.

6 Further reading

Since writing, and especially academic writing, continuously evolves, old references may become obsolete. Make sure that you are using as recent sources as possible. In this sense, online web resources that are timely updated may be the safest choice.

Here is a list of several sources for further reading:

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Acknowledgement

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