

Guideline to scientific writing

Prologue

The purpose of this guide is to provide a basis for scientific writing. It gives an overview of the main structural elements of a scientific text as well as providing general tips for layout and citations.

The main aspect of scientific compared to other writing forms is the purpose. Whereas novels use metaphors and other stylistic elements, in science the main focus lies on **clear, understandable and purpose oriented writing**. This means using short, direct sentences to get the information across. The use of long and complex sentences is often counterproductive and should be avoided if possible. The main theme of the text are the hypotheses of the scientific project and all structural elements aim to proof or falsify them.

Another major difference to other writing forms is proving everything that was written. All information should be either proven by own experiments or using reliable sources. **Reliable sources** are scientific papers, texts and also books that went through a large peer review and therefore are accepted in the scientific world. However, scepticism should be applied to all information used. Ask yourself questions like: **Is this source applicable to my specific case? Are there other sources that are contradicting and why? How old is the data and are there new findings in this area?**

Develop an effective outline

Before you start writing, you should have a good plan. You should develop a kind of “table of content” of your paper, which helps to organize the various topics and arguments in a logical form. It also subdivides the paper writing into a number of smaller tasks. This outline contains:

- The central message: summarize your paper in one (or two) sentences. Rethink your concept if you need more. The central message (and the hypotheses) is the midpoint of the paper around which everything is written.
- Define the principal findings and results
- Sort the key findings in a logical order, and organize and group related ideas together. Shorty write down and structure your argumentation and the conclusions that contribute to each key finding.

NOTE that at this stage you are not actually writing the paper but just put down some notes that guide your thinking.

HINT for beginners: It may help you to select one or two well-structured and well-written papers (akin to your topic) and use them as example.

Structure of the text

As already mentioned in the introduction, the structure of the text should support its purpose and guide the reader easily through the topic. Scientific texts are generally structured as follows:

0. Title
1. Abstract
2. Introduction
3. Material and methods
4. Results
5. Discussion
6. Conclusion
7. Summary
8. References

NOTE that the structure does not necessarily mean that you will actually write your text in this exact order. There are many different ways to approach a scientific work but it is obvious that a summary and an abstract can only be written after having finished the other parts.

Not all papers need conclusions, summary and abstract. Often there is no summary, or some papers require extended enumerated summaries as abstracts.

These headings are the main frame of your work and should be divided into subheadings according to your specific needs. Now we look at the content of these chapters in a bit more detail. Please note that additional reading to the different chapters on the internet might be helpful as this is just a rough overview.

Title

The title has various different purposes. On the one hand it should describe as well as possible the **topic of your work**, while on the other hand maintaining a **short and clear form**. This is often tricky and you will have to find common ground between a four-line long heading describing all your work in detail and a short concise form.

The title should **attract the interest of readers** while using keywords that help putting it into perspective with other scientific work.

NOTE that a common number of words is around 10 – 12 and that the use of abbreviations in the title should be avoided as it might confuse the reader depending on his/her background (for example when talking about organisations or institutions (EU –European Union)).

Abstract

As the title attracts the attention of the reader the abstract determines whether the reader bothers to read the entire text. It contains the **whole work in highly condensed form** including **background, methods, results, discussion and conclusion**. Often the first sentence of the abstract contains the hypotheses (or objectives) and the according methods. This is followed by the major results and conclusions in the rest of the abstract.

NOTE that the abstract should be written in continuous text and not as enumerations of the main points. It should not contain the literature references as this is a waste of valuable space. The abstract should be written last, as it contains the whole work.

Introduction

The introduction contains the **purpose** of your work and puts it into **context** with other scientific research done before. It should describe the **relevance** of your work for example by relating it to current developments in your field (e.g. climate change).

The structure of the introduction should be:

- **Background** of your topic
- The **aim and/or objective** of your work
- Current state according to scientific literature: this is a concise review of the results and findings of other studies so the reader understands the "big picture" and gets the knowledge required to understand the rest of the paper
- Your **hypotheses** should be related to knowledge gaps you identified in the literature review. You may also state which variables and methods you use to support the hypotheses.
- Brief outlook to the parameters you will look at
- **Short** description of your methods

Bringing together your objectives with the current knowledge, you need to establish and convince readers of the **significance** of your work (because only significant texts justify publication). Significance mostly derives from gaps in scientific knowledge or understanding.

NOTE that it is wise to write the introduction first, as it gives you a feeling for your work and forces you to already look at other literature **but** you should revisit the introduction after having written the discussion part as those two parts build the frame of your work and relate to each other.

Write in present tense except for what you did or found, which should be in past tense.

Material and methods

The aim of this chapter is to provide the basis for the reader to **judge your work** based on the methods you used as well as enabling him to **repeat your experiments**. When writing this chapter you should keep the **repeatability** in mind as a help try to answer the following questions:

- What have you done?
- How did you do it?
- What did you use?
- How much?
- How often?
- Where?
- When?
- Why did you choose these materials and instruments?

Simply said, ask yourself if all necessary details are given so that you would be able to replicate the study/experiment?

Often you will use already established protocols and methods. In this case you should refer to the literature you used and describe to what extent you followed the protocol, where and why you adapted it.

NOTE: Don't mix this chapter with the results. It is tempting to already include them here but remember the purpose of this chapter (judgment, repeatability). Further background information and explanations should come in the discussion.

Results

The results document the **outcome of your experiments**. Any interpretation of the data and comparison to other findings should NOT be part of this chapter. This chapter contains the **relevant findings** that help answering your set questions and hypotheses. To do so the main focus should lie on finding the **appropriate form of data presentation**. Think carefully whether the information is best understood in the form of tables, graphs, graphics or in text form. The sequencing of your tables and figures (together with the text) should tell a story, so its important to carefully plan their order (see outline). The order of your results could be from most to least important, chronological or equivalent to the materials and methods chapter.

NOTE: You do not need to describe all data or results, and there should not be redundancy: the text should complement the figures and tables, not repeat the same (e.g. do not include data in graphs which are shown in tables; do not repeat numbers in the text which can be drawn from tables or diagrams.) Instead, summarize your findings, point the reader to the relevant data, important trends (for example use percentage rather than exact data), interconnections between parameters, special features etc. that are important to support your hypotheses.

Discussion

The discussion is the **heart of your scientific text**. You use all the information you gathered in the previous chapter and **connect it to a complete picture**. In the discussion you answer the questions posed in the introduction. Each answer should be supported by either your **own results** or by citing a **literature reference**.

You also **discuss limitations** and possible **errors** of your work. How reliable is the data? Did you encounter any problems in your methods? How significant are these errors?

The main problem of writing the discussion part is to get structure into this chapter. Look at your introduction and the hypotheses you set out to research. Interpret your findings from the results chapter according to these hypotheses, can you support or falsify them? The discussion needs to be structured, often (depending on the journal) by sub-chapters with according heading. A logical structure with sub-headings will support your writing, regardless of whether you can keep the headings or not.

The headings should be as informative as possible: don't use for example "temperature", but tell what is does "temperature influence on growth", or even better, tell the direction of the response "temperature increase limits growth" (which should ideally be a complete answer right in the heading).

Take care not to dwell too much on unimportant aspects. As throughout the whole text, short and precise phrasing is key to success.

A suggested structure for each aspect of the discussion could look like this:

- Re-state the Hypothesis and answer the according question posed in the introduction
- Example
- Refer to your relevant results to support the answer
- compare to literature findings: how does the answer fit with existing knowledge

You will not be able to distinctly link all your results to your hypotheses. Discuss uncertainties in your findings and propose alternative interpretations that you have and that are presented in literature. Also state unexpected results and try to explain them using the information you have.

NOTE: You usually don't add results that have not been mentioned in the results chapter before (apart from results obtained from literature).

Conclusions

This chapter can be understood as a **summary of the discussion chapter**. You focus on the **main findings** of your work without explaining them (that was done in the

discussion part). You put them however into **context** of your knowledge before and draw conclusion that lead to **new research questions**.

These new research questions are the **outlook**. Which questions have not been answered? What could be done next? What where the limitations of your work?

Summary

The summary is a longer version of the abstract. It is around 1 – 2 pages long and should answer the core questions: What has been done? Why has it been done? What where the results?

References

At the end of the text follows the list of literature used in your work. While in the text itself only a short version of the source is listed, here the whole source is mentioned. There are different styles/layouts of reference lists out there and quite a few standards. The most important thing is to be consistent with your choice. Don't mix different styles, but follow a set layout. Ask whether your supervisor has a specific style he prefers and use it. If not go with one of the accepted standards.

An example of how references can be written is as follows:

Books with one author and more than one author

Bartelme, N. (2005): *Geoinformatik - Modelle, Strukturen, Funktionen*, Heidelberg : Springer.

Wieglob, G., Schulz, F. & Bröring, U. (1999): *Naturschutzfachliche Bewertung im Rahmen der Leitbildmethode*, Heidelberg : Physica.

Chapter from a book with different authors:

Felinks, B. (2000): Dynamik der Vegetationsentwicklung in den terrestrischen Offenlandbereichen der Bergbaufolgelandschaft, in: Wieglob, G., Bröring, U., Mrzljak, J. & Schulz, F., *Naturschutz in Bergbaufolgelandschaften - Landschaftsanalyse und Leitbildentwicklung*, Heidelberg : Physica, S. 160-176.

Journal articles:

Weishaar, S. (2007): CO₂ emission allowance allocation mechanisms, allocative efficiency and the environment: astatic and dynamic perspective, *European Journal of Law and Economics*: 24, 29-70.

Risse-Buhl, U., Schlieff, J. & Mutz, M. (2015): Phagotrophic protists are a key component of microbial communities processing leaf litter under contrasting oxic conditions. *Freshwater Biology* 60(11): 2310-2322. DOI: 10.1111/fwb.12657.

[comment: use either official journal abbreviations or journal full names; journal name, volume and page numbers are required, but can also give volume and issue (e.g. 60(11)); sometimes also DOI number is useful]

Online sources:

Agentur für Erneuerbare Energien (2009): *Wärme aus Erneuerbaren Energien* [online], erreichbar unter: <<http://www.unendlich-viel-energie.de/de/waerme/detailansicht/article/6/grafik-forsa-umfrage.html>> [aufgerufen am: 26.01.2010].

There are also different possibilities to structure this chapter apart from the layout. The order of sources can be in alphabetical order of the authors surname for instance. However, there are other possibilities like using enumerations and having the sources appear in the same order as they appear in the text. Talk to your supervisor and check the different styles to find the one that suits you work best.

NOTE: The proper style might also depend on which area your work is in. Natural sciences might follow other rules than engineering and social sciences. Wikipedia is not a reliable source, use web of science and science direct to look for sources. You will have access to these sites via the campus VPN network and the library.

Plagiarism

As mentioned several times throughout this guide you will have to verify your findings with literature. The aim of your work is not to reinvent things that have been proven but to use this knowledge and complete or extend it with your results and conclusions. This means that you will use knowledge of varying sources in your text which is no problem as long as you clearly state where you got the information from. This serves two purposes; Firstly you avoid unbacked comments that you are not proving. Secondly you don't sell findings of other authors as your own.

You should generally avoid to copy and paste phrases or even complete sentences from other papers. If you need to reproduce other author's texts, it has to be set in quotation marks ("...") and cited properly.

Using a table of results from an article without mentioning the source is both unreliable and illegal and will most definitely result in a 5.0 (failed according to the German system). The same applies to copied text passages. It is no comparable to a spelling error or a minor mistake in layout or style. Meaning that plagiarisms is a zero tolerance topic.

Citing correctly

We have looked at the proper way to write a reference list and know about the necessity of using proper sources to avoid plagiarism. But just writing a text and stating the hundred different sources you used at the end of your work is not enough. You have to make sure that the reader clearly sees where the specific information you use in your text comes from. To do so you connect the sources directly to the information you used. This is both true for citations in the text as well as graphs, diagrams, tables, etc. you used from other articles.

When stating something that can be backed up with a certain source you write the source in brackets right after your statement. For example: Climate change is directly

linked to anthropogenic activity (IPPC 2014). You write the author's surname and the year in brackets, all detailed information can then be found in your list of references.

When there is more than one author the following applies:

2 authors: Both surnames and the year (Mutz & Nixdorf 2015)

3 or more authors: Surname of main author plus et al. and the year: (Mutz et al. 2015)

If you do not use a direct copy of a graph or table for instance but take certain information from it simply change the layout you should use the reference as above with an additional statement such as: (Mutz et al. 2015, modified).

You might also find more than one source that you want to use for a specific point you make. Then you will have to divide the different sources by using `;` as shown in the following example:

The river Spree has hydraulic properties similar to... (Mutz et al. 2015; Nixdorf 2008)

Graphs, Lists, tables, etc.

Most of the results are best presented in list, graphs and tables. Using those correctly avoids unnecessary, confusing text. However keep in mind that every graph should be explained and cannot stand by itself.

Apart from an explaining reference in the text everything needs to have a proper title. Usually tables get a title above whereas graphics and diagrams get a subtitle. Furthermore, they all get enumerated according to their type; meaning Figure 1, Table 3, etc.. In the text, the order of mentioning of figure and tables has to match their enumeration, e.g. the first figure to be mentioned has to be Figure 1.

Example 1:¹

Tabelle 2: Variable definitions. Light pollution data is from Cinzano et al. (2001), all other data is from the World Bank (2002).

Variable	Definition
POP1	Percentage of the population living under skies whose artificial glow is greater than the natural level
POP2	Percentage of the population living under skies whose artificial glow is 3 times the natural level
POP3	Percentage of the population living under skies above the threshold pollution level
SURFACE1	Percentage of the surface area with skies whose artificial glow is greater than the natural level
SURFACE2	Percentage of the surface area with skies whose artificial glow is 3 times the natural level
GDP Per Capita	Real GDP per capita in 1996, 1995 U.S. dollars
Urban	Percentage of total population living in urban areas

Example 1 shows a table with proper labelling and title. Note that the table is obviously collected from different sources as stated in the title.

How a graph can look like in a scientific text is shown in example 2 below. Take care that every axis is properly labelled and contains the unit as well. Note how the source is right after the title in the correct format as mentioned in the previous chapter.

Example 2:

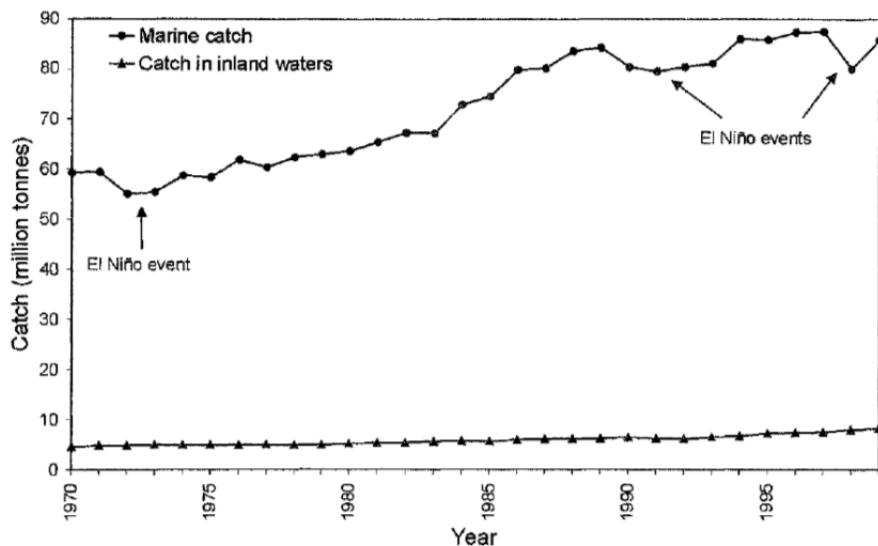


Figure 1: Time series (1970 to 1999) of marine fisheries catches and catches in inland waters
(Source: El Niño events according to WATSON and PAULY 2001). Note, that underreporting of catch by countries and incomplete data on recreational fisheries suggest that catches in inland waters may be at least twice as high as shown on the figure (FAO 1999).

¹Gallaway, Terrel, Olsen, Reed N, Mitchel, David M. (2010): The economics of global light pollution, *Ecological Economics*, Bd. 69, S. 658-665

²Arlinghaus, R., Mehner, T. & Cowx, I.G. (2003) Reconciling traditional inland fisheries management and sustainability in industrialized countries, with emphasis on Europe. In: Hupfer, M., Calmano, W., Fischer, H. & Klapper, H.: Handbuch angewandte Limnologie. VII-2.1, Wiley-VCH Verlag

Basic layout

Apart from the structural elements we have discussed, your work additionally needs a title page including the following information:

- Title of the work
- Type of the work (Bachelor / Master thesis ...)
- Author and matriculation number
- Supervisor (1st and 2nd)

- Study course, name of the module
- Date of submission / project period

The most important aspect concerning the layout is again consistency. The layout structure usually looks like this:

1. Title page
2. Additional statements (if needed an affirmation such as: »*I hereby declare that this thesis is written independent of any unauthorised help. All secondary material and sources are referenced in the thesis.*«)
3. Table of contents, list of figures, list of tables, list of abbreviations, etc.
4. Main part with the structure mention before
5. Attachment (if you have additional material or data that does not fit into the flow of your text)

The choice of your font should be discussed with your supervisor, yet basic requirements are readability and pleasing design. Standard choices for instance are Times New Roman, Arial, Calibri, Book Antiqua (used here) or Garamond. Avoid using fonts that are distracting from the information they contain.

The **standard size is 12** however your headings and titles of tables might deviate from that.

The **line spacing** should be between **1.1 and 1.5**. Again readability is the main focus, but too large spacing to make the text appear more than it is should be avoided.

The **spacing to the sides of the documents** should be chosen that enough information fits on a page, while turning the pages should not interfere with readability (for example **2.5 cm** on each side).

Page numbers should be added to each page of the main document. You may use roman numbers for the various pages of table of contents, list of tables, etc. The page numbers should be either on the right hand side or the middle at the lower end of the page.

Checklist

- Is my writing **clear, understandable and purpose oriented?**
- Did I back up every statement with **data or literature?**
- Are all sources included in my **reference** list?
- Does my **structure** match the requirements?
- Does the title reflect the **topic of my work**, yet is short and **understandable**?
- Does the **abstract** contain all the **major aspects, methods and results** of my work?
- Does my **introduction** state the **purpose, context and relevance** of my work and contain all my **hypotheses**?
- Do my **materials and methods** enable the reader to properly **judge and repeat** my work?
- Did I answer all the **questions in materials in methods** as listed?
- Does the **results** chapter contain all **relevant findings** and are they **presented in the proper way**?
- Do I put all relevant results in the **discussion** into **context with literature** and my **hypotheses**?
- Does the **discussion** deal with **problems** I faced and **limitations** and **errors** of my work?
- Did I draw the correct **conclusion** and made a **proper outlook** for future work?
- Did I use a **consistent style** in my **references**?
- Does the overall **text body** look neat and is everything clearly **readable**?
- Did I use the **same font** throughout my work?
- Is there **enough spacing at the side** to print my work and bind it properly?
- Did I include **page numbers** on every page?
- Are all the **lists** included and numbered with **roman page numbers**?
- Is every **graph and table** mentioned and **explained** in the text in the right order?
- Did I include all **relevant information** on the **title page**?

Additional reading:

One of the most helpful sources are the newsletters of "**San Francisco Edit**". These articles approach such subjects as Writing the First Draft, Writing Effective Results, Methods and Materials, Discussions, Selecting a Journal, Responding to Reviewers, etc.:
<http://www.sfedit.net/newsletters.htm>

George Gopen, Judith Swan (1990): The Science of Scientific Writing. American Scientist.
<http://www.americanscientist.org/issues/num2/the-science-of-scientific-writing/1>

Armstrong, Th., Writing Skills for Academic Purposes: Techniques and Strategies. University of St.Gallen.

<https://www.unisg.ch/~media/internet/content/dateien/unisg/schools/shss/englisch/hs%202015/tom%20hs2015%20writing%20skills%20for%20academic%20purposes%20script.pdf?fl=en>

Lerner, N. & Ogren-Balkama, M.: A guide to scientific writing. Massachusetts Institute of Technology,
http://openwetware.org/images/6/69/Guide_to_Scientific_Writing.pdf