

Introduction

Writing your thesis, whether it is your undergraduate project report, M.Sc, M.Phil or Ph.D thesis, is a daunting and challenging task, particularly when English is not your first language. However, it can be done and it is part of the training to become a scientist. This section provides some useful hints and suggestions. Thesis writing is usually postponed to the last few weeks before submission, it competes for time with data analysis and interpretation, finding the relevant literature to write the discussion, repeating experiments that went wrong, preparing your presentation and many other minor details. Thus it is a good idea to begin writing the thesis from the first day of the research project itself.

A scientific report, thesis, or an article to be published in a science journal follows a similar format, given below:

Title – *Decides if the rest would be read*

Abstract – *What it is all about in a nutshell*

Introduction – *Why was it done?*

Materials and methods – *How was it done?*

Results – *What was the outcome?*

Discussion – *What do the results mean?*

Conclusion – *What was found?*

Literature cited – *The supporting evidence*

This is the general framework, which is followed with small variations. Thus a scientist in any discipline of study knows what to look for and where to find it in a scientific report or thesis.

Language

The language of science is different from literature or fiction. The purpose of scientific writing is to convey to the reader a message without any doubts. There should be no room for different subjective interpretations, as is possible in a work of fiction. The message or idea in a sentence should be precise, without any emotion, unnecessary words or ambiguities (words with double meaning). Science is written in plain, direct, and clean sentences without any hedging. This can be achieved by following a few simple rules.

Quantitative description

Use numbers and not qualitative descriptions such as 'many', 'small', 'large', 'little' etc. These adjectives should be assigned a numerical value. A tall tree is 'Trees greater than 10 m'. Something that is heavy should be given a weight in kg, g, or mg: '2 kg of soil' or '5 mg of a compound' was used. Reference to a time period such as 'brief, after, or long' is given in seconds, minutes or hours. Colour can be described using a Munsell's colour chart. Even subjective adjectives can be quantified by assigning values. The severity of a disease can be quantified by defining a scale of 0 to 10 for the intensity of the symptoms: none, mild, moderate, severe, maximum. By quantifying we avoid ambiguity in our statements and quantities can be analysed statistically.

Words to be avoided

Avoid using words which are vague, undefined and omission of which would not change the meaning of the sentence. Some examples are given below from Katz (2009)¹.

These words have no clear limits

A lot, fairly, long term, quite, really, slightly, somewhat, sort of, very

Words of personal judgment

Beautiful, certainly, disappointing, nice, luckily, obviously, of course

Words that are fillers

Alright, basically, in a sense, indeed, in fact, in terms of, in order to, with regard to
These words have a role in literary or fiction writing but not in science.

The use of tense

Present tense: This belongs to the Introduction and Literature review where statements are made of generally known and accepted facts and citations from published literature. The Discussion is also in the present tense since already published knowledge is being referred to.

Past tense: Your Results have already been obtained – hence this should be in the past tense. Most of the Abstract, which describes your results and the Materials and Methods section, should also be in the past tense.

Title

The Title is what would be read by everybody. Thus each word should be chosen carefully to clearly convey the purpose of the study, without any ambiguity. A good Title should convey with the least number of words the purpose of research reported in the thesis. The Title, along with keywords, are used by indexing and abstracting services to archive publications. These are used by scientists to search for literature for their studies and research. Since we obviously would like others to read and perhaps cite our work, the Title should be carefully formulated. Titles should not contain abbreviations, chemical formulae and jargon.

The choice of the final Title is best done after the research has progressed to a stage, where the end is in sight. In many cases, the focus of the research changes due to unexpected developments while the research is in progress. The final Title should be made in consultation with the supervisor.

Abstract

The Abstract brings together on a single page, the important aspects of the research carried out. The Abstract should contain the following:

- State the principal objective and scope of the research
- Describe briefly the methods used
- Summarize the results, and
- State the principal conclusions

The text should be carefully constructed since after the title, this is what is read and either encourages or discourages the reader from reading further. Clear concise sentences should convey the intended message. The first sentence should state the purpose of the study followed by the methods used. The main emphasis of the Abstract is to describe the results. The final sentences should clearly state the conclusions. References are not included and reference should also not be made to the text in the thesis or any publications. The Abstract should be written after the entire thesis is completed.

Introduction

The purpose of the Introduction is to provide background information and the rationale – the fundamental reason or logical basis - for the study undertaken. It should also state the nature of the problem studied and why it is important. A review of the literature is initially conducted and the relevant copies of the articles

are obtained and read through carefully. The Introduction should set out the known facts – from the published literature – and *point out the gaps that your study seeks to fill*. Explain why you did this study or research project. This should be based on what others have done in the past and also what others may be doing in the present, in the same area of research. Do not go into very specific details – you should not write for the specialized reader. However, if details are necessary include under sub-headings.

The related literature should be discussed by evaluating their relevance to the study. When stating your views in the Introduction (and later in the Discussion), indicate this clearly and separate them from the cited literature. It should be clear to the reader what your views are, and what are the opinions from the published literature.

The research project is conducted to find answers to a research question. The research question under investigation should be explained in a clear and understandable manner so that the reader remains interested to read further. The research question is set out under the objectives or formulated as a hypothesis.

One should not simply ‘cut’ and ‘paste’ paragraphs of literature here. Do not include unrelated material to increase the number of pages. The experts who evaluate and review the thesis would not be impressed and would negatively grade the thesis. The Introduction should be structured with sub-divisions, which contributes to the clarity and enables the reader to locate the desired information. However, too many divisions are to be avoided. A well written Introduction conveys to the reader how much the student has grasped the problem and read the background information and is able to bring this together in the context of the study. Writing the Introduction should begin early during the project.

Materials and Methods

The Materials and Methods section is easy to start with since this is the first thing you would be doing. Describe in detail the methods used in your experiments and the methods. Looking at other theses of colleagues and from the same department, gives you an idea of the format and standards required.

The results of the research project depends on the methodology followed. This section in your thesis should describe the experimental details such that anybody with a similar background and knowledge can repeat and obtain the same results described by you. This section should be accurately reproduced from your laboratory notes.

The laboratory notebook should be recorded in detail as the experiments are in progress (see Chapter 16). You can start by listing all the materials to be used in the experiments and their sources (chemicals, fertilisers, solvents, gases, raw materials, composition of the soil, source of plant materials, etc.). Next comes the instruments used in the experiments from simple items such as stirrers, pH meters, and shakers to more advanced instruments such as centrifuges, spectrophotometers, PCR machines, etc. The operating conditions and other technical details are important for someone else to repeat the experiments. Give details of the instrument manufacturer (name and address or country of origin). It is also important to give climate parameters, either inside the laboratory or outside in the field such as temperature, humidity, light etc. The methods should completely describe the procedures done in the laboratory or the field. If a previously published method is followed, give the citation and any modifications to the method. The experimental design and the statistical methods used to analyse the data to determine the significance of the results should be described. Any software used to analyse the data should be cited with the versions.

A laboratory notebook that has recorded the experimental procedures in detail would facilitate the writing of the thesis and future publications. The goal of the Materials and Methods section is to make it complete, exhaustive and comprehensive.

Results

This is the heart or core of the research project. It contains the new knowledge generated from the experiments conducted and must be reported clearly without ambiguity. This section is built around the data generated from the research project. The purpose of the Results section is to make a story to explain first your general objectives and then your specific objectives. The raw data should be processed using statistics, and these results should be arranged into tables.

Before writing any text, the results should be arranged in a natural sequence to help the reader understand the objectives of the research. This order may not be the order in which the experiments were carried out. This arrangement of results is to carefully build the evidence leading to the final conclusion. All the data in the laboratory or field notebook is not transferred to the thesis. The data should be representative of the experiments. One should select the data that support the experiment when repeated. Thus the variables which affect the outcome of the experiment should be repeated in tables and figures. However, the variables which do not seem to have had any effect on the experiments should also be stated: under the conditions of the experiment the variables tested had no effect on the outcome. It is possible that different results would be obtained under different conditions.

Do not present the same data, in a table and as a figure. By using the data in the tables generate different types of figures such as scatter plots, graphs, histograms, pie-charts and select the best for presentation. Small data sets are best shown in a table, while large data sets are better shown using an appropriate figure. This would show any patterns in the data and also provide the scope of the data. The human mind is able to appreciate visual patterns better than text and numbers.

There should not be any interpretations or conclusions from the data in the Results – this should be done in the Discussion. All numerical data should be first entered into tables with basic statistics such as means, standard deviations, standard errors and significance tests which can be converted to figures as appropriate. Look for trends in the figures as the variables change. Here are some trends to look for:

- At which point is the maximum or minimum reached?
- Is the slope of the curve sharp or gentle?
- Does the slope change into a flat line parallel to the x-axis?
- Where are the data points concentrated?
- How much do the data vary as indicated by the standard deviation?

Discussion

The purpose of the Discussion is to explain the results and show how the different observed facts are connected, from which emerges a simple conclusion. This is done by analyzing the results and comparing them to related research done by others, which are found in the literature. A good thesis is determined by how this section is organized and written. Thus it is important to identify the logical sequence of the findings to be presented.

A good discussion should include the following:

- Begin with a brief summary of the results of the important variables in the experiments conducted.
- What are the relationships between the different experiments to meet the general objectives?
- What generalizations and principles can be drawn from these experiments?
- Indicate any exceptions or deviations from accepted knowledge and what the explanations could be.
- How do your results and interpretations agree or disagree with other published work?
- Are there any new consequences from your findings?
- State the conclusions clearly and give the evidence for each conclusion.

- What is the significance of the entire study?
- A concluding paragraph should bring out the significance of the entire study for the reader. It should relate the objectives or hypothesis that was given in the introduction and relate this to the findings from the study.

Conclusions

After the Title and the Abstract this is what the reader would turn to. A thesis is an extensive description of research and it is useful to bring together in a single paragraph, the final outcome of the study. The Conclusion should capture the outcome of your research project. It should provide answers to the questions raised in your objectives or hypothesis. The text should be modest and not state, what a major achievement you have made! Do not repeat your Results and Discussions. It can either be a paragraph or two, or even numbered statements. The most important or clear-cut outcome is stated first, followed by the next important. Science is open ended and open to controversy – which is how it progresses. You can emphasize, what further questions remain to be investigated and speculate on how the research could be extended.

References

The citations in the text should be accurately included in the list of references at the end of the thesis or paper. To ensure accuracy, always check with the original publication or text book. You should follow the format provided by your institution. Check and recheck with the original – it is amazing the errors that occur with spelling names (particularly foreign names), the initials of authors, volume and page numbers. The internet provides access to at least the Abstract of published papers, if you are unable to obtain the full paper. Never copy references from another paper or thesis – always look at the original. Papers can always be obtained by sending an email to the corresponding author. Citation software such as, *Endnote*, are useful to not only avoid mistakes in citation, but also to automatically include a citation format.

References and Further Reading

1. Katz, M.J. (2009). *From Research to Manuscript – A Guide to Scientific Writing*. Springer

APPENDIX I:

Free Sources of Information

Source	Type of Source	Description
Biomedical literature		
PubMed Central http://www.ncbi.nlm.nih.gov/pmc/	Subject Repository	A free full text archive of biomedical and life sciences journal literature at the U.S. National Institute of Health's National Library of Medicine. 2.5 million articles are archived in PMC.
BioMed Central http://www.biomedcentral.com	Open access publisher	Committed to providing free open access to peer-reviewed biomedical research online immediately upon publication. Covers 241 journals of high impact factor.
Free Medical Journals http://www.freemedicaljournals.com/	Free Journal archive	Free access to the full text of 3223 Journal titles in the fields of Medical, Biology, Cardiology, Endocrinology, and other medical subjects. Depending on the publisher, access is provided immediately or after an embargo period.
HINARI http://www.who.int/hinari/en/	Free/subsidised Journal collection for developing countries	More than 8,000 information resources (in 30 languages) One of the world's largest collections of biomedical and health literature. In Sri Lanka access is available through Health & Medical libraries.
Dove Press http://www.dovepress.com/	Open access publisher	Full text of 180 journal titles.
Physics, Mathematics and Computer Science		
arXiv e-print service http://arxiv.org/	Subject Repository	arXiv e-print service gives open access to over 682,930 e-prints and maintained by the Cornell University.
CiteseerX http://citeseerx.ist.psu.edu/index	Computer Science & Information Science Citation Index	Indexes Academic / Scientific (computer & Information Science.) free web resources – access to 1.5 million documents

Citebase Search http://www.citebase.org/	Citation Index	Citebase Search is a semi-autonomous citation index for the free, online research literature. Harvests Open Access reprints. Contains published articles from physics, maths, information science, and biomedical papers.
ECS Repository - University of Southampton http://eprints.ecs.soton.ac.uk/	Institutional Repository	First academic institution in the world to adopt a self-archiving mandate (2001). All the research output is available and fully searchable in this online repository.
Science Chemistry and Mathematics Preprint Server http://www.chemweb.com/preprint	Subject Repository	The site is a freely available and permanent web archive for research articles. Addition of new items was stopped in 2004.
Agriculture		
AgEcon Search – http://ageconsearch.umn.edu/	Subject Repository	AgEcon Search is a free, open access repository of full-text scholarly literature in agricultural and applied economics, including Working papers, Conference papers and Journal articles.
Organic E-Prints http://orgprints.org/	Subject Repository	An international open access archive for papers and projects related to research in organic food and farming. Contains full-text papers in electronic form together with bibliographic information, abstracts and other metadata.
AGRIS http://agris.fao.org/	Subject Repository	A global public domain Database with over 2 million structured bibliographical records on agricultural science and technology. Some bibliographic references contain either links to full text of the publication or additional information.
Social Science		
SSRN (Social Science Research Network) http://www.ssrn.com/index-cm.html	Subject Repository	The vast majority of papers in the SSRN eLibrary are downloadable at no charge. It covers information from 20 Social Science related networks. In addition, SSRN provides free subscriptions to its abstracting eJournals to users in developing countries on request.

OAPEN : Open Access Publishing in European Networks http://www.oapen.org/	Open Access Subject Repository of European Books	OAPEN is a collaborative initiative to develop and implement a sustainable Open Access publication model for academic books in the Humanities and Social Sciences. Aims to improve the visibility and usability of high quality academic research.
Geosciences		
Open access journal tiles in Geosciences http://www.geoinfo.org/geooajour.html	Geosciences	Information on over 60 Open access journal tiles in the field of Geosciences.
Multidisciplinary		
Socol@r – http://www.socular.com/?ver=en .	Open Access Journal Gateway	One stop search for all the open access information worldwide. 11739 Journals including over 2 million articles.
Open Science Directory http://www.opensciencedirectory.net/	Gateway and Global search tool for all open access journals	Open Science Directory contains collections of Open Access Journals (e.g. Directory of Open Access Journals) and journals in the special programs (Hinari, Agora, OARE). About 13,000 scientific journals are now available in the 'Open Science Directory'.
Directory of Open Access Journals (DOAJ) http://www.doaj.org	Open Access Journal Repository	Free Full text access to over 8256 journals and nearly a million articles. Of these, 4068 journals searchable at article level.
Highwire press : http://highwire.stanford.edu/lists/freeart.dtl?sa=X	Free Journal Repository	Over 2 million free full-text articles and over 6 million total articles. 21 sites with free trial period and 54 completely free sites. 275 sites have free back issues, and 1334 sites have pay per view.
Inter Research Science Centre http://www.int-res.com/journals/open-access/	Open Access Publisher	Provide's open access to 2 journals.
J-STAGE - https://www.jstage.jst.go.jp/FF01S010Init?sourceurl=%2Fbrowse%2F	Japanese Journal Gateway	J-STAGE is an electronic journal site operated by the Japan Science and Technology Agency and makes available to the public via the Internet electronic journals issued by Japanese academic institutions and other contents.

Public Library of Science- http://www.plos.org/publications/journals/	Open Access Publisher	Open access to full text of 7 journal titles.
Hindawi - http://www.hindawi.com/journals/	Open Access Publisher	Open access to more than 300 Open Access journals.
Wiley Open Access - http://www.wileyopenaccess.com/details/content/12f25d1df44/About.html	Open Access Publisher	Open access to full text of 32 journal titles.
Oxford Open Journals – http://www.oxfordjournals.org/oxfordopen/	Open Access Publisher	Open access to full text of 17 journal titles.
Springer Open - http://www.springeropen.com/journals	Open Access Publisher	Open access to full text of over 100 journal titles.
Elsevier Open Access http://www.elsevier.com/journal-authors/open-access/open-access-journals	Multidisciplinary Open Access Publisher	Open access to 107 titles.
EBSCO – Inter Research Science Centre – http://www.int-res.com/journals/open-access/	Open Access Publisher	Biological, Computer, Mathematics, Stats, Medical, Physics, Astronomy, Religion, Philosophy, Arts etc.
Academic Journals http://www.academicjournals.org/journals.htm	Open Access Publisher	Provides free access to research information to the international community without financial, legal or technical barriers. All the journals from this organization will be freely distributed and available from multiple websites.
e-Asia Digital Library http://e-asia.uoregon.edu/	Repository and Gateway to Asian Books	e-Asia is a collection of digitized e-books and a database of full text web resources. It strives to contribute to the research and scholarship of East Asia. e-Asia project is funded by the University of Oregon Library.
DART (http://www.dart-europe.eu/About/info.php)	Open Access Repository of Post Graduate theses	Access to over 320,000 open access research theses from 432 Universities in 24 European countries.

<p>ETHOS: UK Dissertations/ Theses http://ethos.bl.uk/Home.do</p>	<p>Gateway and search tool to British Post Graduate theses</p>	<p>ETHOS offers a hub, which automatically harvests e-theses from Institutional Repositories and digitises paper theses from participating institutions in the UK to offer the single point of free access. Over 300,000 records. Full text is on payment.</p>
<p>Open Access Repository Indian theses http://eprints.csirexplorations.com/ Council of Scientific and Industrial Research, India</p>	<p>Multidisciplinary Post Graduate theses</p>	
<p>Theses, Dissertations & Graduate Projects, Queens University, Canada http://qspace.library.queensu.ca/handle/1974/196</p>	<p>Post Graduate theses</p>	<p>Free access to a large collection of theses of the Queens University, Canada.</p>