



Best practice guidelines

WASP (Write a Scientific Paper): How to write a scientific thesis



A B S T R A C T

The prospect of writing a thesis is considered daunting by many but the task is a requisite when embarking into reading for any academic degree. A thesis is a written document following personal research. It is performed to obtain an academic degree or qualification, both at undergraduate and postgraduate level. When writing a thesis, it is imperative that the student follows the universal well-acknowledged structure format known as “IMRAD”: i.e. Introduction, Methods, Results and Discussion. A summary of the thesis, known as the ‘Abstract’, is placed at the beginning of the “IMRAD”, while all references cited in the thesis are placed at the very end. The thesis format is similar to a research manuscript prepared for publication in scientific journal, but there are significant differences between the two types of academic works. For example, the liberal use of graphical aides in the form of figures and/or tables enhances the delivery of results. It is essential to ensure that all the literature referred to in the thesis is cited, while paying particular attention to potential plagiarism. When writing a thesis, the student needs to keep in mind three factors: [1] the structure, [2] the substance and [3] the style. Once the student has developed a good plan for thesis layout, then writing becomes greatly facilitated.

1. Introduction

A thesis is defined in the Oxford Dictionary as “*a long essay or dissertation involving personal research, written by the candidate for a university degree*” [1]. A thesis, known also as a dissertation, can be a requisite for both pre and post graduate courses. The majority of students consider the task of writing a thesis as daunting and potentially boring. However, the experience of working on a thesis often lays the foundations for developing skills that translate into lifelong benefits [2]. The format for writing a scientific thesis has been formally established, thus helping to provide a basic structure around which to create one's own masterpiece. The structure format is broadly based on the “IMRAD” structure: i.e. Introduction, Methods, Results and Discussion.

When required by a university to prepare a thesis, the student is assigned a personal supervisor who oversees and guides the thesis writing. The length, depth and research quality of the thesis itself will vary according to the level of the academic degree one sets out to achieve. Furthermore, it is customary for the candidate to also undergo an oral defense of his/her work when reading for a postgraduate academic degree.

2. Thesis vs a research manuscript

A research manuscript written for publication in a professional journal aims to disseminate interesting or important findings resulting out of a research-based study. The length of this manuscript is often specifically limited by the journal editor with a word count restricted to 2,000 to 6,000 words depending on the type of manuscript being submitted and the journal's preference. An original scientific work is usually permitted a greater word count than a review or an opinion. A research thesis submitted as a requirement for an academic degree may provide a number of scientific publications suitable for different journals. The journal ensures that the submitted manuscript is refereed in a single or double-blinded review process. Those research manuscripts meeting the journal's scope and having answered the journal referees

concerns will eventually be published. In the case of ‘open access journals’, the author may need to pay an article processing fee prior to the publication of the manuscript [3].

A thesis, on the other hand, is an academic document set up to answer a research question/s. The process generally starts by the student forwarding a research proposal to the faculty with specifically identified research questions and proposed methodology. This is backed by a critical review of the relevant literature that enables the research questions to be posed. Once the research is undertaken and completed, a critical appraisal of the research performed becomes necessary to situate new findings within the broader picture of extant knowledge of the subject.

A thesis demands a degree of originality unless it is based solely on a critical analysis of existing theories or viewpoints. Each university will set its own regulations for the presentation style and length of the thesis. These generally depend on the research area, being different in the science faculties as compared to the humanities. It is therefore useful for the writer to refer to past theses accepted by the Faculty in order to get an idea of the preferred style and format. As in all research publications, a thesis requires very accurate referencing and avoidance of intentional or unintentional plagiarism. Students undertaking a thesis (especially for an MPhil or a PhD) are encouraged to try to publish different parts of their thesis in peer-reviewed journals prior to submission of the thesis. Successful publishing will empower the thesis itself as it provides direct credit to the quality and level of the work performed by running it in advance through the peer-review process [4].

3. Structure of a thesis

Thesis has been written down the centuries with varying formats depending on the secular styles current at the time. In the twentieth century, most universities have adopted a standardized structure known as the “IMRAD” - Introduction, Methods, Results and Discussion) [5]. The structure of the scientific thesis is therefore

generally similar for most universities and institutions, although it is important to check the required structure with the faculty prior to starting the writing process. The recommended thesis format is as follows [6]:

- Preface
- Introductory Section
- Materials and methods (including statistical analysis)
- Results
- Discussion
- Conclusions
- References
- Appendices

The Preface of the thesis should include the Title page, the Table of Contents and the list of figures and tables, a list of Abbreviations used commonly in the text, and finally any Dedications or Acknowledgements. There should also be a (usually structured) Abstract summarizing the important aspects of the research.

The title page should include the title of the thesis centred on the page. The font size of the thesis title is usually one to two font sizes larger than the text that follows. Next comes the full name and qualifications of the student presenting the work, followed by the name of the institution to which the thesis is being submitted. Finally, the degree for which the thesis is being submitted and the year of submission is typed in a separate line. Graphic design is essential since the thesis must attract the visual sense of the assessor. The title page needs to be followed by the *Declaration of Authenticity* statement. This is a signed declaration that the work being submitted is the student's original work and has been gathered for the purposes and objectives of the study. Furthermore, the student declares that the work has not previously been submitted to any other institution for a higher degree.

The Table of Contents includes all the major divisions of the thesis including sub-sections along with their corresponding page numbers. A distinction between the major divisions and the minor subdivisions should be clearly visible. This is usually performed by the use of capital letters and indentations [7]. The preface pages (from Table of contents up till Abstract) are numbered in roman numbers (i, ii, iii, etc.) whilst the remaining subsections are page numbered in Arabic numbers (1, 2, 3, etc.). The *Table of contents* page is usually not included in the preface numbering. Document writing software programmes, such as Microsoft Word, have features that make life easy for the student allowing the use of different heading styles according to the importance of the thesis divisions. When the thesis writing is finished, the writing software constructs the table of contents automatically (insert – table of contents).

The list of figures and the list of tables follow the same format. Each figure/table is numbered in Arabic numeral in the order of appearance along with the title of the figure/table and the corresponding page number. The writing programme software being used can also automatically create these lists pages.

A List of Abbreviations used throughout the thesis will help the reader refresh his memory should the need arise. Abbreviations should also be written out in full on the first occasion they are mentioned in the text.

Acknowledgements and dedications are important. It is paramount that all the people involved in the research and in the thesis writing process are acknowledged. The first acknowledgement should of course be towards the individuals who have particularly assisted and supported the research work including the supervisor/s, co-supervisor/s and adviser/s, including the statistical adviser/s. All the people or institutions that have helped out such as colleagues, fieldworkers, laboratories etc need to be acknowledged. In addition, any funding bodies should be mentioned. At the end, it is customary to acknowledge all those who have 'put up' with the emotional roller coaster that accompanies a thesis. These are usually family and friends, with the

occasional pet thrown in.

The Abstract should be a formally structured one that addresses the background of the study, the objectives set, the basic methodology, the important results and the important conclusions of the research. Acceptable word counts for the structured abstract vary between institutions, but generally approximates 400 words. No citations are required within the abstract. The abstract should provide answers to the questions: "What was done?" "Why was it done?" "What question was set to be answered?" "How was it done?" "What was learnt?" "Why does it matter?" [6].

The 'background' section clarifies the significance of the study in a clear and concise manner. The context and rationale for performing the research study need to be defined. The 'objective' section needs to contain a clear statement of the research question/s and the purpose for conducting the research. The 'methodology' section needs to be basic and only give an outline of the type of research conducted and parameters assessed. The full detailed methodology that would suffice to allow any other researcher to replicate the study should be provided as part of the write-up further on in the thesis. The 'results' section needs to be concise and illustrate the most important findings of the research study. The information in this section needs to be consistent with the information provided in the rest of the thesis. Only the established main conclusions need to be stated in the 'conclusion' section.

The Introductory section of the thesis should start by with an Introduction to set the scene relevant to the topic, motivate the reader to continue reading by describing the problem under study, underlying the importance of the topic chosen to research, ending with a chapter by chapter outline of the thesis. The next chapter should include a critical review of the literature.

Performing a literature review may be considered daunting especially if the research area is extensive. The literature review is undertaken at a relatively early stage in the research and if performed well will help grease the gears for a smoother ride in later stages. This section should be as comprehensive as possible within the space available. This review should detail all that is known about the topic and perhaps more importantly, what is not yet known, laying the stage for the rationale and justification of the thesis. This critical review will thus help define the hypothesis and research questions that will be address in the study. It is not enough to summarise the research literature in a form of precis, but the student needs to show an understanding of the relevance and significance of the different publications in relation to the scope of the current research study. The candidate should further analyse the literature in order to identify the common strands and differences between published results as well as to highlight the strengths and weaknesses of the previously published research.

It is of utmost importance that the aims and objectives of the research study are kept in mind while compiling the literature review, in order to avoid including everything under the sun! All sources utilized to compile the literature review need to be cited. Generally, all cited sources should be primary sources to avoid using other peoples' interpretations of published sources. The preliminary literature review should have been completed before setting out the Research Proposal since the definition of the research hypothesis and research questions should be based on the information available. This section should however be constantly updated to include any new concepts or findings published subsequently that are relevant to the research question along the course of the study period. The period between submission of the thesis and the viva examination (if applicable) should also consist of reviewing the literature for any important work that may have been published during this time period. It is also useful to include the methodology used to facilitate and carry out the literature search, i.e. the search strategy – which search engines and what search terms were used; the Inclusion and Exclusion criteria used; and any assessment tools used if an analytical comparison of the relevant literature is included, e.g. CONSORT Guideline for randomised controlled trials.

The literature review should have clear subheadings to facilitate

reading. It is generally useful to (insofar as possible) mirror subheadings in the main parts of the thesis, i.e. in the literature review, the methodology, the results, and the discussion. This makes referring back from one section to another easy for the reader.

The following is a checklist to ensure a sound literature review [8]:

- The Topic is carefully analysed;
- The key aspects of the topic are identified;
- The key terms are defined;
- The organisation of the review is explained;
- Literature review uses primary research from peer-reviewed journals;
- The research is summarised in one's own words;
- The published research is evaluated and summed up; and
- Areas for further research in the topic are identified.

The final part of the ‘Introductory’ section should include the research hypothesis and research questions being posed by the study. This will further define the aims and the list of objectives set out to be achieved by the research project. The aims are general statements concerning the overall goals or intentions of the study. The objectives are the individual stages that the research must achieve on the way in order to reach the goals set out at the start. This section should serve as the continuing beacon for the whole research project that is planned and targeted with the primary scope of achieving the set objectives, reaching the set aims, and answering the research question/s. A link between the goal of the research and the literature review needs to be present. Table 1 demonstrates the *Introduction* section assessment categories used by examiners when correcting a thesis [9].

The Methodology section needs to answer the ‘what’ and the ‘how’ of the proposed study. It should have sufficient information to allow any other researcher to replicate and confirm the work being presented. Hence, a detailed description of all the study populations, the materials, procedures, theories and definitions used in the research need to be included in this section, along with all the calculations, techniques, equipment and calibration plots used. The inclusion and exclusion criteria need to be stated clearly. If there are multiple study groups, it may be clearer to describe the groups using a Flow Chart Structure such as the CONSORT Flow Diagram Format. After all, ‘A picture is worth a thousand words’. Furthermore, all analytic methods followed during the study, including references to any specialized statistical software need to be mentioned in this section. One should continually update this section while undertaking the actual research. This will avoid missing any crucial details as well as leaving fewer tedious tasks to wrap up at a later stage.

This section should demonstrate complete understanding of the methods used to answer the research question. It is essential not to omit any important information that portrays the logic of the study as well as to judge the adequacy of the method used [10]. It is important to detail the ethical concerns related to the study and how these were addressed. This is particularly important when human or animal studies are involved. The different subheadings of this section vary depending on the type of research being performed. A possible example could be [4]:

- Subjects
- Design
- Materials, apparatus and procedures
- Statistical analysis
- Validity and reliability of method
- Ethical considerations

Table 2 demonstrates the *Materials and method* section assessment categories used by examiners when correcting a thesis [9].

The Results section is the heart and soul of the thesis. A clear and sound argument along with interpretations of specific results should take center-stage in this section. It needs to show the student's logic of inquiry while analyzing and reporting the results obtained in the research performed. All positive and negative results are to be mentioned. The use of tables and figures may enhance the delivery of the results. However, repetition should be avoided. Information provided in graphical (table or figure) format should not cover information found within the main text. As a general rule, text should be used when the data being described is limited; tables when there is a copious amount of data to be described; and figures where trends or correlations are available. If tables or figures are used, these must be referred to in the text in summary. The tables and figures should be simple to interpret, without any obscure colour combinations – remember that examiner/s may be colour blind. A concise self-explanatory title should always accompany the tables and figures – these should be stand-alone sources of data. (4). It is ideal, whenever possible, for the tables and figures to follow the same format throughout the whole thesis. When reporting a statistical analysis, the significance should be quoted in the form of a *p*-value, even if the analysis was not found to be significant. Table 3 demonstrates the *Results* section assessment categories used by examiners when correcting a thesis [9].

It is suggested that, whenever possible, the order of the results follows the same order of the subheading in the corresponding literature review within the introduction section. For example, if in the literature review, diabetes was discussed first followed by obesity, the results covering diabetes should come before the results covering obesity. This will facilitate the examiners' perusal of the thesis. It is essential to keep in mind that a happy examiner leads to a happy student. The same principle applies for the discussion section.

The Discussion section is the ‘thinking part’ of the thesis. The student needs to discuss the findings while showing an understanding of why such a finding was present. This includes the formulation of theories and suggestions to explain the results. It is essential that the findings be compared to previous studies. Ideally these should have followed a similar methodology as the work presented in the thesis, although this may not always be feasible. The study's results may be in agreement or disagreement with previous work. In either case, the student needs to justify or theorize on the probable reason/s for such findings. It is essential for the student to make it clear which of the statements are observations and which are interpretations. At the end of the discussion, it is customary to include the study's strengths and limitations [6]. The study limitations should be clearly identified and discussed. All studies have limitations. The perfect research study does

Table 1
Introduction section examiners assessment checklist [9]

PhD	Pass	Fail	
MSc	Pass with distinction	Pass	Fail
BSc	Pass Gr A - distinction	Pass Gr A - D	Fail
	<ul style="list-style-type: none"> • Reason for and importance of study clearly stated • Link to literature clear • Theories/concepts apt, clearly defined, reflect understanding. • Terms clearly defined. • Research questions/hypothesis clear, testable, based on literature 	<ul style="list-style-type: none"> • Reason and importance of study stated • Link to literature unclear • Theories/concepts apt, defined, show fair understanding. • Terms not always defined. 	<ul style="list-style-type: none"> • Reason and importance of study not stated or referenced • No link to literature • Theories/concepts not defined or inappropriate, show no understanding. • Terms not defined. • Research questions/hypothesis not or poorly stated, not testable, no link to literature

Table 2
Materials and method section examiners assessment checklist [9]

PhD	Pass	Fail	
MSc	Pass with distinction	Pass	Fail
BSc	Pass Gr A - distinction	Pass Gr A - D	Fail
	<ul style="list-style-type: none"> ■ Methodology well described allowing for easy replication. ■ Methods/tools are suited to relationships between variables; test for validity done. ■ Research design & setting fit purpose of study. 	<ul style="list-style-type: none"> ■ Methodology described but not clearly making replication of study difficult. ■ Methods/tools suited to show relationships between variables; test for validity poorly done. ■ Research design not fully described; adequate for purpose of study 	<ul style="list-style-type: none"> ■ Methodology not described sufficiently to allowing for replication. ■ Methods/tools are not suited to relationships between variables; tools not validated. ■ Research design & setting not described or do not fit purpose of study.
	<ul style="list-style-type: none"> ■ Study populations well selected, clearly described 	<ul style="list-style-type: none"> ■ Study population selection not clearly described; may not be ideal sample. 	<ul style="list-style-type: none"> ■ Study population not described and does not fit study goals
	<ul style="list-style-type: none"> ■ Ethics carefully considered and described. 	<ul style="list-style-type: none"> ■ Ethics may be considered but not in their totality. 	<ul style="list-style-type: none"> ■ Ethics not considered or not described.

Table 3
Results section examiners assessment checklist [9]

PhD	Pass	Fail	
MSc	Pass with distinction	Pass	Fail
BSc	Pass Gr A - distinction	Pass Gr A - D	Fail
	<ul style="list-style-type: none"> ■ Statistics mainly inferential, well suited to study. 	<ul style="list-style-type: none"> ■ Statistics mainly descriptive, but appropriate to study. 	<ul style="list-style-type: none"> ■ Statistics not described or inappropriate to study.
	<ul style="list-style-type: none"> ■ Method of analysis well described; results easily verified 	<ul style="list-style-type: none"> ■ Method of analysis well enough to verify results. 	<ul style="list-style-type: none"> ■ Method of analysis poorly described; results cannot be verified
	<ul style="list-style-type: none"> ■ Data collection unbiased; presentation logical, relations between variables well stated. 	<ul style="list-style-type: none"> ■ Data collection unbiased; presentation sometimes illogical, relations between variables not well stated. 	<ul style="list-style-type: none"> ■ Data collection biased; data confusing & illogical, relations between variables not stated.
	<ul style="list-style-type: none"> ■ Tables/figures well organised, stand alone, support narrative; relate to text & emphasise results. 	<ul style="list-style-type: none"> ■ Tables/figures not so well organised, do not stand alone; generally relate to text & emphasise results. 	<ul style="list-style-type: none"> ■ Tables/figures not organised, include unimportant data; do not relate to text.

Table 4
Discussion – Conclusion section examiners assessment checklist [9]

PhD	Pass	Fail	
MSc	Pass with distinction	Pass	Fail
BSc	Pass Gr A - distinction	Pass Gr A - D	Fail
	<ul style="list-style-type: none"> ■ Discussion of results logical, nonbiased, organised, clearly reveals patterns/relationships. 	<ul style="list-style-type: none"> ■ Discussion of results clear, nonbiased, presented systematically. 	<ul style="list-style-type: none"> ■ Discussion biased or illogically presented; hard to follow or understand.
	<ul style="list-style-type: none"> ■ Relevance of results to theories and important literature well discussed & referenced. 	<ul style="list-style-type: none"> ■ Relevance of results to theories & literature mentioned. 	<ul style="list-style-type: none"> ■ Relevance of results not discussed or incorrect.
	<ul style="list-style-type: none"> ■ Limitations of study clearly identified and discussed. 	<ul style="list-style-type: none"> ■ Limitations of study not clearly identified. 	<ul style="list-style-type: none"> ■ Limitations of study not stated.
	<ul style="list-style-type: none"> ■ Future relevant research suggestions given. 	<ul style="list-style-type: none"> ■ Future research suggestions have little relevance. 	<ul style="list-style-type: none"> ■ No proposals for future research direction.

Table 5
Reference section examiners assessment checklist [9]

PhD	Pass	Fail	
MSc	Pass with distinction	Pass	Fail
BSc	Pass Gr A - distinction	Pass Gr A - D	Fail
	<ul style="list-style-type: none"> ■ Sources in reference list cited correctly in the text; style apt and consistent. 	<ul style="list-style-type: none"> ■ Sources in list may not all be cited in text; style consistent. 	<ul style="list-style-type: none"> ■ Sources in reference list not cited in test; style not apt and inconsistent.
	<ul style="list-style-type: none"> ■ References current, mainly primary. 	<ul style="list-style-type: none"> ■ References current, but many secondary. 	<ul style="list-style-type: none"> ■ References not current, many secondary.

Table 6
Appendices section examiners assessment checklist [9]

PhD	Pass	Fail	
MSc	Pass with distinction	Pass	Fail
BSc	Pass Gr A - distinction	Pass Gr A - D	Fail
	<ul style="list-style-type: none"> ■ Appendix complete, well organised, support study. 	<ul style="list-style-type: none"> ■ Appendix relatively complete, generally support study. 	<ul style="list-style-type: none"> ■ Appendix not organised, incomplete or irrelevant to study.

not exist. For this reason, the student needs to be humble and state all the limitations present.

One must make sure that the Research Question proposed at the start of the study has been addressed and answered, and that the aims and objectives identified prior to undertaking the study have been addressed.

The Conclusion should provide a take home message for the reader. It should be concise and state the main findings of the study, while avoiding repeating the results or the discussion. This is followed by Recommendations for further research (if applicable) with the aim of supporting, validating or continuing on the work already performed. No research study can expect to fill in all the blanks in knowledge related to the subject at hand, and furthermore research can itself raise new questions. Table 4 demonstrates the Discussion - Conclusion section assessment categories used by examiners while correcting a thesis [9].

Plagiarism has a very broad interpretation but is generally understood to be the appropriation of somebody else's work or ideas passing these off as your own. In other words, plagiarism is a form of fraud that universities take very seriously. While it is accepted that one must refer to other people's previous work to place one's research within the broader picture of knowledge, one must be very careful to attribute any source of information or ideas that one may be quoting or relying upon.

Any data taken from any source needs to be paraphrased and not cut and pasted, even if the data has been cited. There are readily available and accessible online programmes that can check theses for the possibility of plagiarism – intentional or accidental. It is becoming customary that universities require their students to submit the thesis to such software prior to the official submission of the work.

The Reference list should include all the literature sources used within the thesis. These need to be acknowledged through citations within the text and a reference list at the end of the thesis. There are a number of different referencing styles available, the most common being the Harvard and Vancouver reference styles. It is important to know the particular style of referencing required by the Faculty so that one cites and references in the correct manner from the very beginning. Examples of both types of referencing styles are provided below:

- Harvard style: The in-text citations should include the author/s surnames (up to three authors, followed by ‘*et al.*’ if more than three authors are present. This is followed by the year of publication. At the end of the thesis within the ‘Reference’ section, the whole reference is written. The order of referencing at the end is based on the alphabetical listing of the first author’s name. An example of a Harvard reference for a journal article is as follows:
 - Grech, V and Cuschieri, S. (2018) Writing a scientific paper (WASP) – a career critical skill. *Early Human Development Journal*. 117:96 – 97. DOI: 10.1016/j.earlhumdev.2018.01.001
- Vancouver style: The in-text citation should be in Arabic numbers. There are variations as to how such a citation number is written i.e. whether it is within brackets or square brackets or superscripted at the end of the sentence. It is important to identify the correct format from the Faculty. At the end of the thesis within the ‘Reference’ section, the whole reference is written in order of appearance in the thesis. An example of a Vancouver reference for a journal article is as follows:
 - Grech V, Cuschieri S. Writing a scientific paper (WASP) – a career critical skill. *Early Human Development Journal* 2018; 117:96 – 97. DOI: 10.1016/j.earlhumdev.2018.01.001

In contrast to thesis written for the humanities, footnotes are not used in a scientific-based thesis. It is essential to keep a standard format especially when it comes to journal names. The journal names should be either all abbreviated or else all written in full. It is suggested not to have references older than 10 years. Older references are to be kept to a minimum and used only if the reference is of utmost importance to the study. Table 5 demonstrates the *Reference* section assessment categories used by examiners while correcting a thesis [9].

The Appendices should host all the data pertaining to the study that was not required in the main text but might be important for the examiner to review the thesis or for anyone wishing to replicate the study. Information placed in this section includes: copies of questionnaires used, consent forms, any information sheets used as well as permissions granted. It may also include data that was used to illustrate graphs in the text, e.g. secular trends of a disease prevalence. The appendices do not fall under the remit of the word count of the thesis. This however precludes it from being used to “dump” essential data for fear of exceeding the maximum word count. Table 6 demonstrates the *Appendices* section assessment categories used by examiners while correcting a thesis [9].

4. Conclusion

A thesis is a storyboard set out to tell a research story; from what

literature is already out there, to the reason as to why another research study is required (the gap for new research), how such a task was performed and what came out of it. This is then followed by comparisons and justifications of the results that were established and what was the main message. A thesis is by no means a simple task and cannot be taken lightly. However, aides and guides are in place to help the students on their journey. There are three aspects that the student needs to keep in mind: [1] structure, [2] substance and [3] style. Once the student gets to grips on what needs to be done, understands the ‘why’ such research is required and what story needs to be unveiled, then it becomes a home run till the end.

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Conflict of interest statement

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