Dr. Norbert Cheung's Lecture Series

Level 5 Topic no: 41

Research Report and Presentation (part 1)

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1. Introduction to Academic Writing
2. Elements of Report and Thesis

Reference

Engineering Research: Design Methods and Publication, Herman Tang, Wiley, 2021.

1. Introduction to Academic Writing

#1 Academic writing is an integral part of the research activity

For the most part, do not consider a research project complete until the research outcomes are reported and the report itself is accepted by the funding sponsor or government agency. For example, industry-sponsored research projects often require that we submit the reports and any artifacts to our sponsors. For research projects supported by government and non-profit organizations, we are normally required to publish papers in scholarly journals or professional conferences, in addition to regular and final reports. For large projects spanning multiple years, we need to submit annual reports as required for continued funding in subsequent years.

#2 Research writing is not creative writing

A research report is more so expository writing rather than creative writing, which largely relies on a writer's inspiration and imagination. Academic and scholarly writing have standard formats, expectations, and stylistic guidelines to follow. We should decide on two things before writing: (i) the type of report and (ii) writing plan.

#3 Important requirements of research writing

- *Objectiveness*. To report technical contents, our objective statement is based on data obtained from technical work and free from any kind of ambiguities. The process, derivation, interpretation, discussion, and conclusions should all be supported by the domain principles and study results.
- *Directness*. We should avoid any type of implicitly and directly state as much as possible on all assumptions and considerations.
- *Descriptiveness*. We need to explain the important aspects of research, such as experiments, process steps, and parameters, detailed enough to be repeatable to get the same results.
- *Clarity*. We must write from the perspective (background and needs) of the readers. We keep them in mind and convey complex technical information in an appropriate manner.
- *Format*. Professional associations, such as Institute of Electrical and Electronics Engineers (IEEE), American Society of Mechanical Engineers (ASME), and American Institute of Aeronautics and Astronautics (AIAA), have discipline preferred formats and styles. We should use them. In addition, we use the terminology that is commonly used in the particular fields.

#4 Elements of research report/paper

A research report or paper is composed of several sections. Figure 8.1 shows a typical framework of the sections in a report or paper. However, not every report has to have all these sections. In terms of their significance, we may categorize these sections into three levels: key, core, and supporting.

This model in Figure 8.1 is purpose built with the reader in mind. When reviewing, readers normally read the title, abstract, and conclusions first to know an overall picture of a report. In other words, these three sections give the critical impression to readers. If they were interested, they would likely continue to read the sections of problem statement, methods, results, and discussion, which are the main efforts of research work and writing-up. We will discuss all of them more in the following subsections of this chapter.

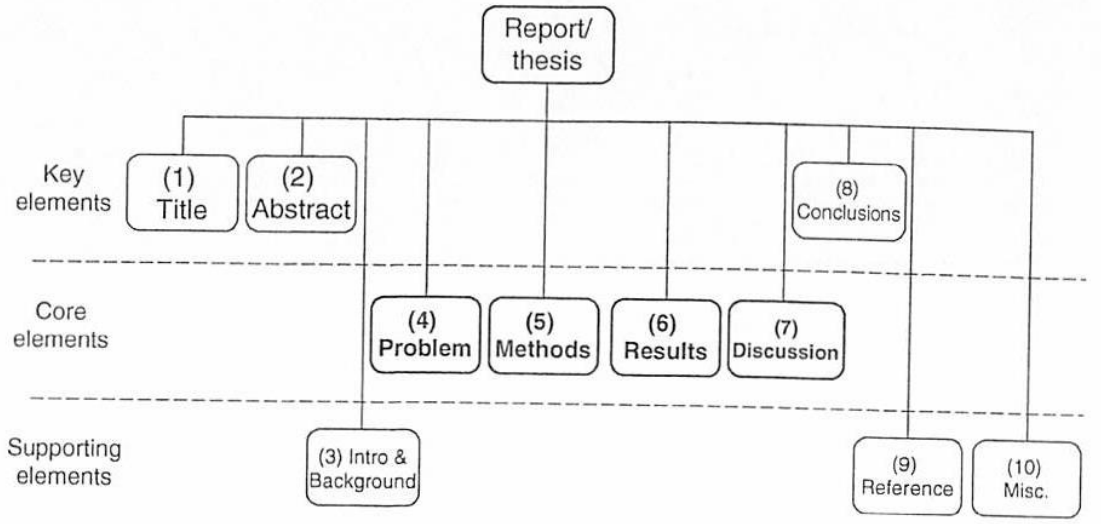

Figure 8.1 Composition of research reports and papers.

#5 Thesis and Dissertation

A master's student may need to complete a thesis and a doctoral student must do a dissertation based on their research. A thesis or dissertation is a detailed research report to show student's research achievements and qualification to obtain an advanced degree.

Figure 8.2 shows a typical structure for theses and dissertations. A master's thesis normally has one research topic to cover, while a doctoral dissertation has up to four chapters on specific research topics.

A master's thesis often looks like a long research report, while a doctoral dissertation may be more analogous to a book – a few related topics (chapters) bound by an introduction, literature review, and conclusions. A chapter of a thesis and dissertation may be further developed into a scholarly paper for publication.

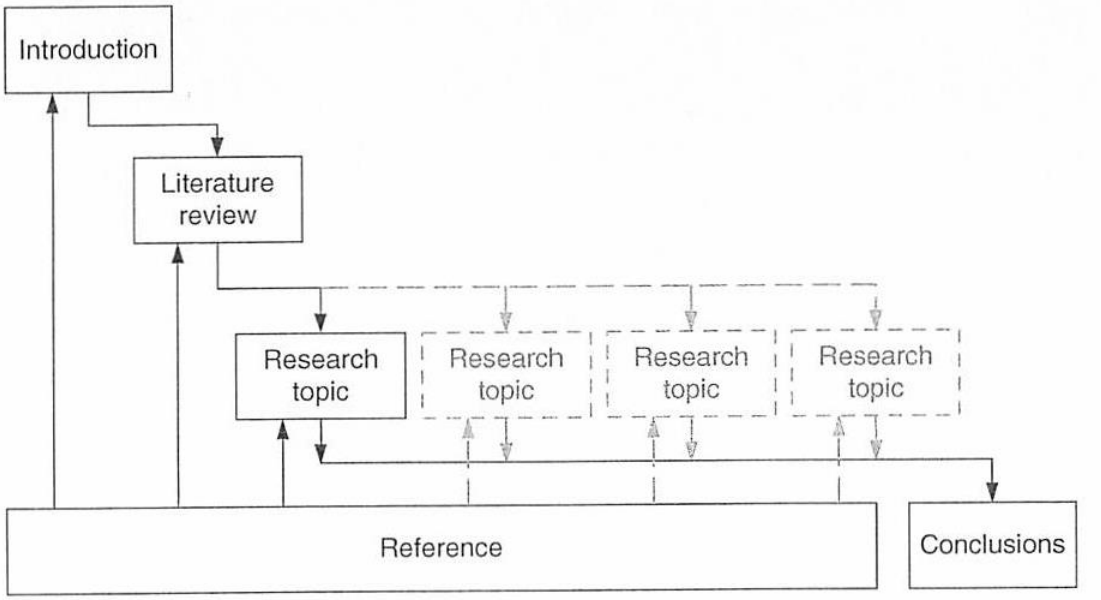

Figure 8.2 A typical structure of thesis and dissertation.

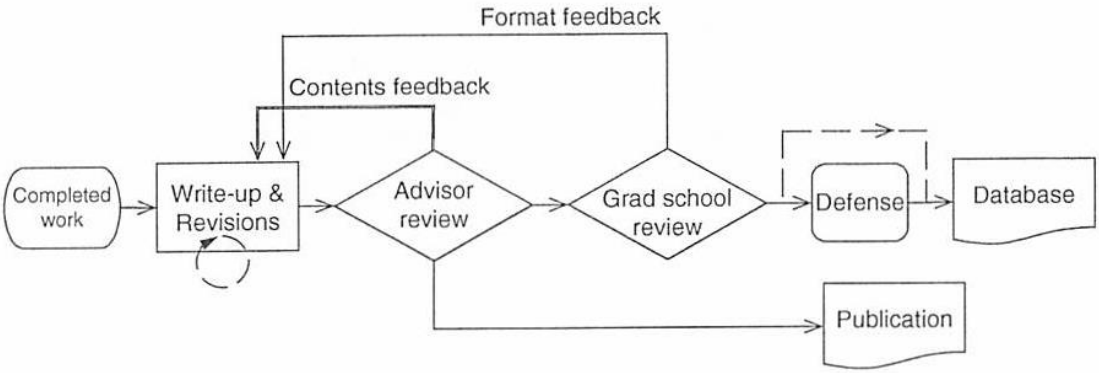

Figure 8.3 A process flow of thesis and dissertation preparation.

For doctoral students, publication of two to three journal papers is required for the successful completion of a dissertation. The number and quality of publications are very important for their career as a scholar in an academia or research institute. Master's students, if conducting research projects, are often expected to publish one paper.

#6 Report of the project

A research project report is a summary for internal review and reporting purposes. The reports often give a statement, process, and the results of research, as either a final or periodic report, to upper management or a sponsor. For student research, students need to submit project reports after finishing their research projects.

#7 Elements of the project report (an example)

1. Cover Page Data Elements
2. Accomplishments
3. Products
4. Participants and Other Collaborating Organizations
5. Impact
6. Changes/Problems
7. Budgetary Information
8. Demographic Information for Significant Contributors

#8 Types of research reports

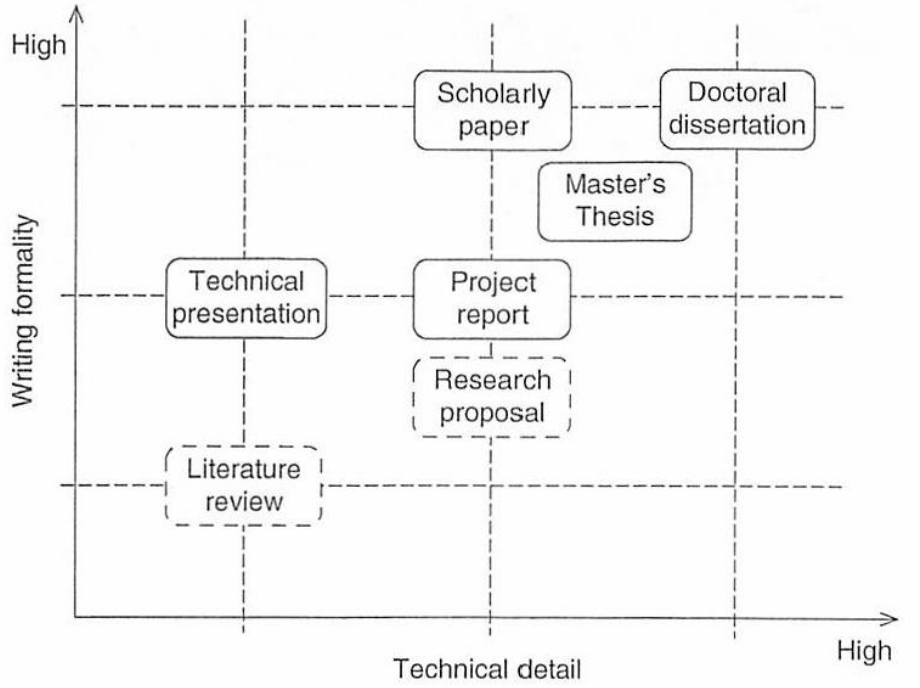

Figure 8.4 Formality and detail of technical reports.

#9 Differences between technical report and scholarly paper

Due to the large diversity of technical reports and scholarly papers, their characteristics overlap. For example, scholarly papers may have future potential commercial value. Many corporations, particularly large companies, conduct basic research but do not publish all their research outcomes.

Table 8.1 Technical reports vs. scholarly papers.

Aspect	Technical report	Scholarly paper
Purpose	Internal reference, may related to financial benefits	Contribution to body of knowledge, not have immediate financial benefits
Accessibility	Restricted and limited	General public
Review	Internal reviews by superiors	External peer-reviews, normally in blind, with a specific rubric
Quality	Various	Consistently high
Proprietary	Normally yes for data and conclusions	No sensitive/confidential information, approval of publication maybe needed
Length	Normally less than 3000 words	4000–7000 words
Format	Various	Consistent and fixed
Summary	One-page executive summary	Abstract, 100–200 words
Author	Team and department	Individual author(s)
Copyright	Organization	Individual authors or organization

2. Elements of Report and Thesis

#1 Key Elements

(1) Title

Almost all readers view the title of a report or paper first. If the title is clear and relevant, they will go to the abstract, etc. A paper title with an abstract can make a difference between your article being read or not. Thus, a paper title should be very clear. In addition, a title should be sufficiently specific where readers can understand the research subject and focus without reading the paper contents.

Example:

"Torsion sensing based on patterned piezoelectric beams" (Cha and You 2018)
"Autonomous vehicles: challenges, opportunities, and future implications for transportation policies" (Bagloee et al. 2016)
"Development of a weighted probabilistic risk assessment method for offshore engineering systems using fuzzy rule-based Bayesian reasoning approach" (Ung 2018)

(2) Summary and Abstract

An executive summary provides brief information for a quick assessment. For internal reports, an executive summary or abstract is required, which is summarized from the sections of *(4) Problem Statement, (5) Research Methods, and (6) Results* without details and explanation (refer to Figure 8.1). In other words, an executive summary has at least three building blocks, as shown in Figure 8.5. When necessary, a brief information from *(3) Introduction/Background and (8) Conclusions* may be added in. For scholarly papers and theses, the summary is called abstract, which will be more discussed in the next chapter.

Due to the limited space, a summary is pure text, without figure, symbol, equation, or reference. Abbreviations used should be limited to the well-established ones, such as CAD and AI, by the professionals in disciplines.

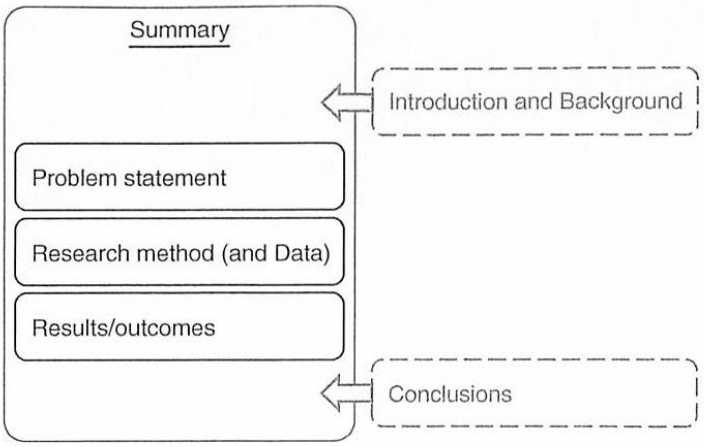

Figure 8.5 Key information in an executive summary.

(8) Conclusions

Similar to the executive summary or abstract at the beginning of the paper, this section is a summary to the overall paper. However, the main difference is that the conclusion section focuses more on research achievements. It also connects the broader context of the research work to the research outcomes, without introducing any new information or insights. Readers often go to the conclusion section after reading the abstract of a report or paper for more information on the research results. Therefore, a conclusion section should be significantly different from an executive summary or abstract.

A conclusion section highlights the main findings and concise interpretations based on results and discussion. It would not be a good idea to repeat or add more discussion in a conclusion section. The key information in a conclusion section consists of (see Figure 8.6):

1. Restatement of the research problem and concise summary of work (one paragraph)
2. Summary of results and findings to the problem (three to four bullet points or sentences)

In addition, it is beneficial that the conclusion section contains the information of (one or two paragraphs):

3. Contributions to the body of knowledge and/or professional community
4. Research limitations under a specific circumstance or weaknesses
5. Viewpoints on future work to do

For regular reports and papers, including student's theses, the conclusion section should be about a half page long. For doctoral dissertations, they often have one or two pages.

#2 Core Elements

(4) Problem Statement

In this section, we define a research problem to solve as well as sub-problems if applicable. The arguments and motivation to solve the problem can come from innovative ideas, requirements from fieldwork, continuation of a prior work of the research group, and/or from a literature review. The basic requirement of this section is the clarity of the addressed problem.

Example:

"The problem can be stated straightforward: Control the bounding box of an SCQC by controlling the distillation frequency." (Paler 2018)

Example:

> *"This work proposes a decision-making model, motivated by emerging CPS technologies, that solves the problem of identifying the most profitable and most environmentally-friendly production plans of a product while ensuring manufacturers achieve optimal costs and equipment uptimes."*

Immediately following the problem statement, the authors claimed the needs of working on this problem (some details are removed and replaced with "…" for a simplicity purpose):

> *"In this problem, the product designer wishes to…."*
> *"In this problem, product designers submit details of their part…."*

Then, the authors mentioned the factors associated the problem:

"Raw material costs and processing costs are considered."
"The problem is defined with a gate-to-gate system boundary and requires…"

Following, the authors proposed some details of the problem solving:

"To solve this problem, the following parameters/data are required: …"
"Noteworthy assumptions include: …"
"Major decisions include: …"
"Following precedent set in the manufacturing supply chain literature, a bilevel programming (BP) model is developed to represent the Stackelberg game structure …."

In summary, a problem statement should be clear and may be in different styles, such as a single sentence, a paragraph, or even a section. The problem statement can be either a standalone sentence or accompanied with its background, justification, and explanation in a section.

(5) Research Methods

In this core section, we discuss a method for specific considerations, assumptions, parameter settings, procedures, etc. If a method is not commonly used, then we should describe it in appropriate amount of detail so that readers can fully understand the study.

In most cases, we divide this method section into three to five subsections – each dedicating to a specific item, such as data measurement, computational technique, analysis, etc. There are large variations in data analysis and method utilization, depending on the nature, objectives, and focus of a research project. Therefore, researchers often label the method section differently. Figure 8.7 shows two examples (Oks et al. 2018; Ribeiro et al. 2018) of method sections. In the two examples, one proposes a new method; the other explains the experiment used.

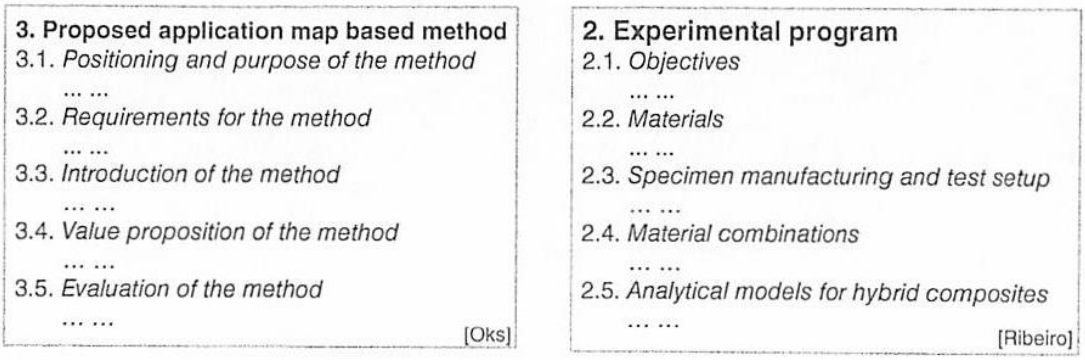

Figure 8.7 Examples of research method section.

(6) Results and (7) Discussion

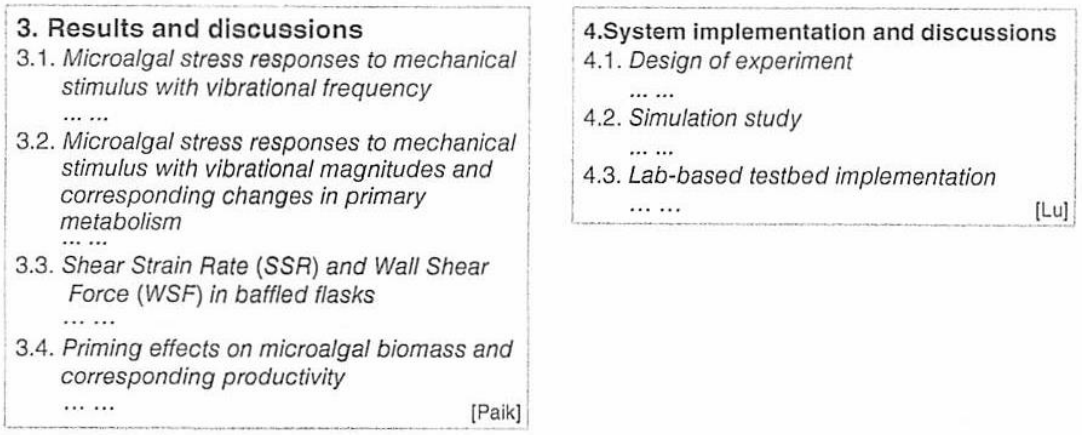

Figure 8.8 Examples of result and discussion section.

Technically, these two sections can be presented separately. In a results section, we describe results without much interpretation, with a dedicated discussion section following. For a relatively large research project, the discussion section may start with a summary paragraph of an overview of the completed work.

However, many authors prefer combining the two sections into one section, labelling it as "results and discussion," based on the main achievement points. In such a combined section, we show research achievements following the analysis and results. Then, we offer our understanding and interpretation of the intrinsic meanings of those analysis results. To generalize our conclusions, we need to provide validation and justification in discussion.

#3 Supporting Elements

(3) Introduction

The introduction of a research report and paper is the overall context and background of the research for readers. An introduction should convey four pieces of information: background, status, research overall, and report outline (see Figure 8.9). The literature review is often embedded in the introduction sections. Sometimes, literature review can be a standalone section.

In the introduction section, we normally start opening phrases with the background of the research project and then talk about the status of the research topic. With the solid support of both background and status from a literature review, we introduce our research as a problem to address: justification of the study. Most researchers also briefly present their paper outline at the end of an introduction section.

(9) Reference

We have discussed the role and significance of references in Chapter 2 for research proposals. Similarly, the reference section is an integral part of a technical report and academic paper, too. Using references, we not only honor other researchers' credit but also have a support to our research. Unfortunately, the reference section is omitted in many internal reports. Appropriate citation is important to avoid unintended plagiarism.

Generally, only the references with in-text citations should be listed. Authors may cite their own previously published works, but the self-cited items should be limited as a very small portion of the total references. The reference section does not normally include personal communications, un-refereed conference proceedings, or commercial (.com) website addresses, unless necessary.

(10) Miscellaneous

There may be additional small subsections in research reports and papers, such as,

Acknowledgements. In this optional subsection, we thank our funding sponsor and recognize other people who contributed to the reported work. The acknowledgement may be just one sentence or a short paragraph at the end of a report and paper. For a master's thesis or doctoral dissertation, the acknowledgement goes to the advisor, committee members, and researcher's family, placed in a preface.

Appendices. An appendix may be included in a report or paper if necessary. Some researchers use appendices to provide supporting details and keep the main text concise. Most reports and papers do not have an appendix. For students' theses and dissertations, an appendix is considered chapter equivalent regarding the format.

Lists of Figures, etc. For a long report, such as a master's thesis or doctoral dissertation, a list of figures, a list of tables, and a list of acronyms are often necessary. Such lists offer the reader's convenience to aid in comprehending the file.

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