Tampereen yliopisto

Author

GUIDE TO WRITING A THESIS IN TECHNICAL FIELDS

Instructions for Master of Science and Bachelor of Science theses

Technical fields
Master's Thesis guide
January 2019

ABSTRACT

Author: Guide to writing a Thesis in Technical Fields: Instructions for Master of Science and Degree programmes in technical fields
Master's Thesis guide
January 2019

Preparing a thesis requires that students have acquired thorough knowledge of the subject and possess the ability to find relevant information effectively and to work independently. This guide contains general instructions for writing a Master of Science (technology) thesis at Tampere University. It introduces students to the basic elements of clear and unambiguous technical writing. These guidelines are intended for master's theses, but may be applied to bachelor's theses as well as other reports.

Master's studies provide students with the necessary foundations and skills to pursue scientific research. First and foremost, research must be objective, reliable and repeatable. The five main steps of the research process are planning, information gathering, re-search work, analysis and reporting. Scientific writing can be considered as a means of clarifying one's own thinking. Hence, it is an essential part of the research process and gradually pulls your plans, results and text into a coherent whole.

A logical structure ensures that the reader can easily follow your line of inquiry. Consequently, theses and scientific articles have very similar structure: the background, what was done, and the results. The writing style is also important. Scientific text, including references, must be written and formatted according to the provided instructions. Fig-ures, tables, and mathematical notations enable you to present a great deal of data in a clear and concise format.

Whenever you refer to someone else's work, the original author must be properly cited and acknowledged. The most serious mistake thesis writers can make is to take credit for other people's work. Consistent use of references allows the reader to locate the original sources. In addition, proper citations help you present the background and related work in a condensed form.

Key words: thesis, writing guide, thesis structure, thesis layout, references, Master of Science, Bachelor of Science

The originality of this thesis has been checked using the Turnitin OriginalityCheck service.

PREFACE

This guide is intended for Master's and Bachelor's Theses at Tampere University. This guide is applicable in the technical fields of Tampere University, but the degree programmes may have issued additional instructions for students writing their thesis. In case of inconsistencies between this guide and degree-specific instructions, please follow the instructions provided by your faculty. Other fields at Tampere University have their own thesis guides. The guide is mostly based on the Tampere University of Technology's previous thesis writing guide and relevant literature.

This guide is intended for students who are writing their Bachelor of Science or Master of Science thesis in English in technical fields. The guide is primarily written in accordance with the instructions provided herein, with the exception that, for example, the author's name is not displayed above the title on the title page. The thesis type in the abstract is either 'bachelor's thesis' or 'master's thesis', but here it is 'thesis writing guide'. The list of abbreviations includes some terms that do not have to be defined in theses, such as *ed*. and *et al*. Students are also encouraged to use more figures and tables than in this guide. The reader is addressed perhaps more directly in this guide (*do this*) than most theses. Example sentences are both italicized and placed inside quotation marks, even though only of these typographical techniques is enough for actual quotations.

The original instructions were compiled by a working group of teachers and experts at Tampere University of Technology and it has now been updated for the new Tampere University.

In Tampere, Finland, on 16 January 2019

Author

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LIST OF FIGURES

LIST OF SYMBOLS AND ABBREVIATIONS

CC license	Creative Commons license
ed.	editor or edition
et al.	Latin et alii or et alieae, and others
LaTeX	typesetting system for scientific documentation
SI system	Système international d'unités, International System of Units
URL	Uniform Resource Locator
vs.	versus

a	acceleration
B	magnetic field
div	divergence
F	force
$f(x)$	value of funktio with argument x
grad	gradient
$\mathbf{L}$	angular momentum (operator)
m	mass
sin	sine function
T	temperature
$\mathbf{u}$	vector
$\underline{u}$	vector, alternative notation style
v	velocity
$\mathbf{v}$	velocity vector
V	vector group
x	x coordinate
y	y coordinate

1. INTRODUCTION

Students prepare a thesis to demonstrate their proficiency and competence in their chosen field of study. A thesis may focus on empirical research, planning and implementation, or be a review of existing research literature. Writing is a form of communication. Even the most ground-breaking research findings are meaningless, unless they are documented and made publicly available. It is essential that university students learn how to carry out research that meets professional standards. In addition to a BSc and MSc thesis, students complete a wide range of coursework and written assignments that train them in scientific writing and the responsible conduct of research. This document is a comprehensive guide to writing a research paper in technical fields at Tampere University. This guide assists students in the preparation of written assignments, bachelor's theses, master's theses and other reports. Separate guidelines are available for students writing a doctoral dissertation

The requirements of written assignments vary greatly. For example, a master's thesis is more extensive than a bachelor's thesis (30 credits vs. 10 credits). The scope of assignments may differ, but their structure is nevertheless very similar and thereby allows the reader to focus on the content. If you know how scientific papers and essays are structured, you will find it much easier to both read and write scientific texts.

For research results to be of value, they must be *objective*, *valid* and *reliable*. Researchers must remain open-minded and never allow their preconceived notions guide interpretation (objectivity). The results must represent the phenomenon that the researcher is claiming to measure (validity), and other researchers must be able to carry out the same experiments and achieve the same results (reliability).

Writing helps you clarify and stimulate your thinking. When you are conducting research, you review existing literature, collect data, analyse your findings and draw conclusions. Writing is an integral part of the research process. Few writers are able to produce polished text straight away, and it is normal that you continue to refine your thesis throughout the process. You need to know how your thesis adds to the existing pool of knowledge in your area of interest, so it is very important to include a review of previous research in your thesis and always give proper credit to the original sources. Your research builds on existing research. And if you do not read, it is difficult to write.

When you start your research project, you should allow enough time for collecting data. Initially, it may be challenging to identify the right keywords and locate relevant articles from extensive databases. It may be helpful to attend the training sessions on information retrieval that are offered by the University Library and through Moodle.

Chapter 2 of this guide outlines the guidelines for scientific writing and good scientific practice. Chapters 3 and 4 offer information on the structure and style of scientific texts. Chapter 5 provides an introduction to common citation styles and Chapter 6 to the University's requirements concerning the layout of your thesis. The appendices include templates of the title page and abstract and a list of suggested sources of further information. The basic principles of scientific writing are universal, but, for example, the citation style may depend on the academic discipline involved. In addition to this general guide, students should refer to possible additional instructions provided by their own faculty.

2. SCIENTIFIC WRITING

The purpose of scientific writing is to disseminate knowledge. It is a process whereby ideas are verbalized and complex and occasionally tangled thoughts are organized into a coherent and logical whole. The process requires not only time, persistence and determination but also creativity.

2.1 Stages of the research process

Writing is an integral part of the research process (Figure 1). It is a fluid, iterative process and writers move back and forth between the stages of prewriting, drafting and revision. It may be helpful to apply project management principles to your work.

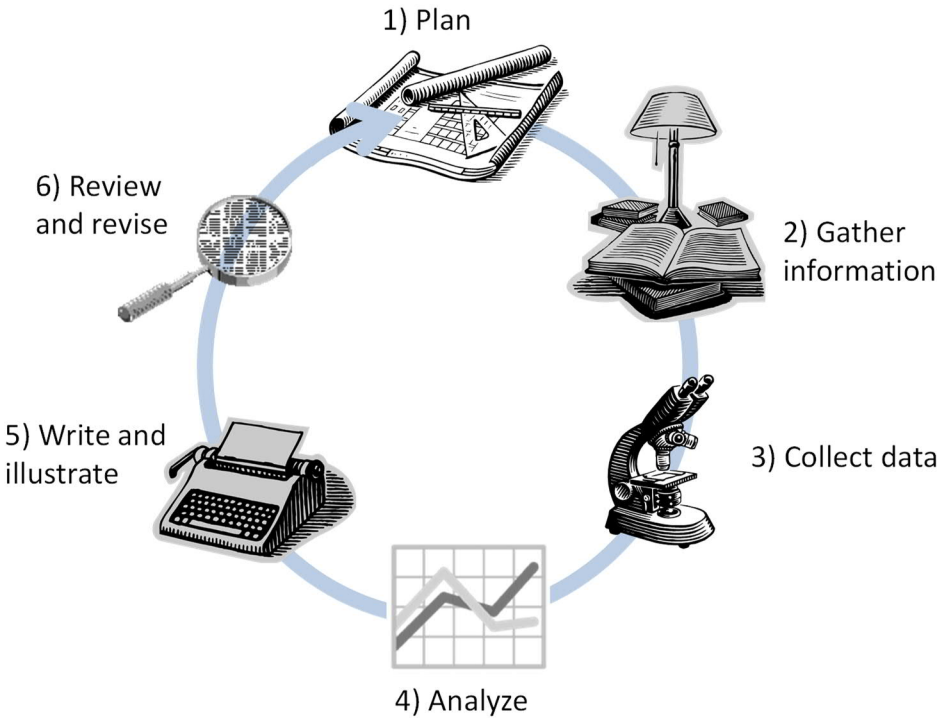

Figure 1. *Main stages of a research process.*

The research process begins with you defining your key objectives, setting milestones for your writing, and preparing a preliminary schedule in cooperation with your supervisor and perhaps with the organization that has employed you as a thesis worker. Then you start gathering information by reading existing literature and consulting your supervisor and colleagues. As a thesis is a relatively short-term project, you gradually narrow down your topic; one person cannot solve all research problems. However, in some cases you can draw a general conclusion from narrowly defined, specific observations.

The next stages of the research process reflect the novelty of your research: data collection and analysis. Depending on your area of research, your research materials may comprise measurement results, a device, software, action plan, literature, case studies or interviews. At the analysis stage, you turn raw data into understandable information that can be interpreted, for example, by calculating indicators (minimum and maximum values, average values and standard deviation), visualizing data (graphs, tables, diagrams) and comparing your data to previous research findings and theories. In addition, you address any deficiencies that you may notice in your thesis or background materials at this stage.

The simplified illustration above seems to imply that the writing stage begins late in the research process. In reality, it is good writing practice to continue redrafting and revising your thesis throughout the process, so you need to start writing early on. Later editing ensures that your findings are expressed clearly and logically. Unclear text is most often the result of the author's unclear ideas. The second most common causes are a lack of finishing touches and consideration for the reader.

Courses on scientific writing often focus on teaching the participants how to write texts and reports for others. Before you write for others, you need to be able to write for yourself and keep doing so throughout the research process. Writing for yourself helps you clarify your thinking and promotes learning and understanding, whereas writing for others is communication. Writing is not about recording perfectly formed ideas. Instead, it is a process that stimulates your thinking and allows you to work through your ideas and make new connections.

2.2 Writing for yourself

When you write for yourself, you are essentially using effective note-taking strategies. You take notes while reading scholarly literature on your topic, making observations based on your research results and jotting down your thoughts and 'aha moments.' These notes may go through several drafts but form the basis of your thesis. Writing a thesis is not a solitary pursuit, and you need to produce text and draw pictures simply to discuss your research with your instructor. Comprehensive notes prove surprisingly valuable, when someone has to refer to your work years from now.

There are many different methods of note-taking, and whichever you choose depends on your personal preferences and what works for you. The pen-and-paper approach is effective in many situations, but a wide range of electronic note-taking applications is

also available, allowing you to easily share your notes. For example, you can use concept or mind maps to outline the topic of your thesis. They are diagrams showing how words, ideas or concepts are linked together.

It is good to remember that note-taking is skill that you will perfect over time. You will gradually develop a method that works best for you.

We should all use the writing technique that comes naturally to us. The process presented in this guide is based on the extensive experience accumulated over the years by thesis instructors, so it is an excellent starting point for beginning writers.

2.3 Writing process

The prewriting stage is the most neglected stage of the writing process. It may not even be perceived as a part of the writing process, because not much text is produced during this stage. As lack of planning will come back to bite you, you should devote enough time to prewriting. If you dive into writing your thesis without a plan, you may run into problems later on, but you must also avoid the trap of excessive planning and procrastination.

You should consider the following basic questions at the prewriting stage:

1. What is my main message and goal? Answering this question helps you stay focused and maintain consistency. Explain what makes your topic interesting for your readers.
2. How do I narrow down my topic? You need to stay on topic and omit irrelevant points. Describe how your research contributes to the current pool of knowledge, so that your reader can understand the importance of your findings.
3. Who am I writing to? Consider how much background information you need to include in your thesis to ensure that readers can follow your thinking. Scientific texts and theses are written for professionals who are familiar with your field. They, too, may need to be reminded of some of the details.
4. What is my schedule? Remember to leave enough time for prewriting and revision, not just the writing process. Writing is difficult without a clear plan, and rewriting is an essential element of any good writing.

You **gather information** for your thesis by reading existing scholarly literature on your topic and collecting background materials. You will continue to refer back to existing literature and your research materials throughout the writing process, but you need to be sufficiently familiar with your topic and relevant terminology and research methods before you put pen on paper. You will have to go through at least dozens, often even hundreds of information sources to produce a thesis. You need to assess the reliability of your sources before referring to them in your thesis. Publications that have undergone a peer review are considered more reliable than non-peer reviewed papers.

The University Library has put together a list of useful links. In addition, the Library offers on-campus access to a broad range of electronic resources free of charge.

When you **start writing** your thesis, the first task is to prepare a preliminary table of contents that provides an overview of your thesis as a whole. Write down tentative titles for all the chapters, summarize the main points that you intend to discuss in each chapter, and consider the placement of the key tables and figures. To outline how thoroughly you plan to discuss your points, you can assess how many pages each chapter will take. It makes a difference whether you plan to spend 0.5 or 5 pages discussing your theoretical framework. Once you have created an outline of your thesis, it becomes easier to focus on the details.

After you have prepared the table of contents, you do not have to start writing from the beginning. You can basically start by writing any chapter that seems easy, such as your results or the theoretical framework. Remember to make sure that your thesis has a logical flow and, for example, that all concepts are explained beforehand. You will update and specify your table of contents along the way as you revise your thesis.

The actual **writing and editing stage** is usually the most time-consuming part of the process. It means you have to sit down and produce text, graphs and tables. Thanks to the plans you made at the prewriting stage, you will know exactly what you are doing and what you need to accomplish. There is no point in waiting for inspiration. You can even force yourself to start writing, and gradually the writing will stimulate further ideas and you will see yourself becoming more enthusiastic.

Do not worry about spelling or punctuation at the drafting stage, as you will revise the text later on. Say what you need to say directly and briefly. The time to rewrite and edit the text becomes later.

You need to allow enough time for writing your thesis. You are making excellent progress, if you produce 1–3 pages of quality text or figures in one day. Use the thesis template for technical fileds for formatting your thesis right from the beginning. Give consistent names for the different versions of your thesis, such as *lastname_title_msc_v01_2014_04_01.tex*. One or two keywords from the title may suffice. A version control system, such as Subversion [1], automatically records the changes you make to your thesis over time. However, mark some version identifier, such as "*v01*", to the file name when you submit the draft to your instructor. And always remember to back up your documents, preferably on different types of media.

Polishing and finalizing the text take more time than many would assume, but they have a significant impact on the quality of your writing. Instructors cannot usually give very specific feedback on the initial drafts of your thesis, and their comments tend to become more detailed as the work progresses. Furthermore, instructors do not want to

repeat their comments, so please be sure to make the requested revisions before submitting a new draft to your instructor.

First you need to make sure that the structure suits the content. Your thesis needs to be logically and coherently organized. It is likely that you have to rewrite or delete some parts, but your previous work is not wasted. Practically all writers need to revise their introduction and the chapter discussing the theoretical framework, so that they fit in with the rest of the paper, but this usually takes a couple of days at most. Then you should focus on the details and then on the presentation of your thesis, such as word order, sentence structure, the placement of tables and figures, consistency of notations, and citation style.

Your schedule should allow a couple of days' leeway, so you can wait a while before returning to the text and reviewing it with fresh eyes. Writers often become blind to their own mistakes, so it is a good idea to let some of your friends read your thesis. Carefully proofread your thesis for grammatical errors and check that terminology is used consistently.

2.4 Getting started on writing your thesis

Writing is not easy, but a positive attitude goes a long way. Your attitude largely determines how difficult or easy writing or any other work feels like. Writing takes time and effort but not unreasonably so. Be sure to start the writing process as early on as possible.

It is important that you establish effective routines for writing. We should all develop regular writing routines that ease us into the writing zone on good days and bad days. The best way to identify the routines that suit us best is to read and write. We read quality works to become better writers, and learn to avoid the mistakes of others when we encounter bad writing.

Students working on their thesis are entitled to appropriate supervision and support. You write your thesis independently, but it does not mean the same as alone. Feedback from peers and the scientific community is an essential part of the scientific writing process. Ultimately, the purpose of your thesis is to demonstrate your level of expertise, but you do not have to write it in solitude without feedback and supervision.

Procrastination and other scheduling problems are common phenomena. When you start working on your thesis, you should set yourself a proper schedule with clear milestones. The schedule must be realistic but ambitious. University graduates are expected to have the self-discipline to stay on schedule.

You should also start the actual writing process early on. Otherwise you will not have enough time left to take a little break if you get stuck and let your subconscious mind go to work for you. You will have to go through every little detail systematically at some point, but it may be best to focus on the details later on, rather than start by checking them all.

Perfectionism has many faces and is a common obstacle to productivity. Students may, for example, be afraid of not living up to the standards imposed on their writing. Have you set yourself realistic or unreasonably high expectations in terms of your thesis? Keep in mind that your thesis is not your life's work. Some of us put off handing in papers and essays, waiting to get them just right. We should all remember that our texts will never be absolutely perfect. We need to learn to let go – we should pursue excellence, not perfection.

Fear of failure is common among writers and manifests in many different ways. It may discourage students from showing their unfinished work to others. Such a fear obviously increases the risk of failure. Students need to seek feedback and discuss their thesis with others to ensure that they stay on the right track.

It is also possible that students unconsciously lower their expectations to avoid potential disappointment. We all need to get rid of these unhealthy thought patterns and do our best to excel. Some students may have had negative experiences of writing at school. Do not hark back to the past; this is a new place, a new time and a chance to start afresh.

2.5 Good scientific practice

Science seeks to explain the natural world [2]. Research is a systematic and rational activity that aims to generate new knowledge that builds on existing knowledge. Of all the theses written by students, only doctoral dissertations are expected to meet all the requirements of rigorous academic research.

The established research methods vary between disciplines. So-called fundamental or basic research is not geared towards commercial applications. Scientists with an interest in natural sciences create hypotheses and test their hypotheses through experiments and observations. For example, physicists can verify the accuracy of calculated trajectories by conducting measurements, whereas mathematicians prove their statements systematically by logical deductions (proof). Applied research that aims to find answers and solutions to practical problems is more common in the field of industrial management and other engineering sciences, such as mechanical engineering. Applied research projects often focus on developing new or analysing existing equipment, buildings, materials

or methods. The results of applied research are compared to alternative solutions and substantiated through measurements.

All research involves presenting statements and reasons supporting the claims. A hypothesis must be stated in a way that makes it possible to reject it (falsifiable). It there is no logical possibility that a statement could be shown to be false by a particular observation or physical experiment, the statement lies outside the scope of science. These principles often apply to scientific writing in general.

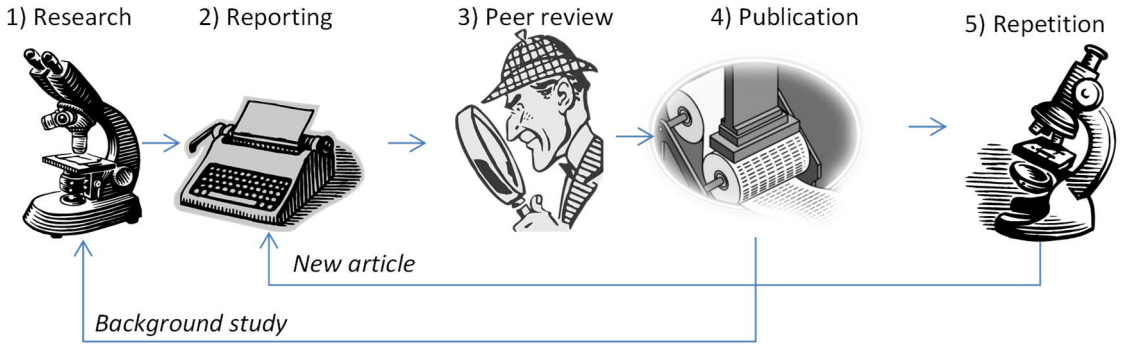

Figure 2. *The 5 main steps of the scientific method.*

Simply put, the scientific method includes the following five steps: *research–reporting–peer review–publication–repetition*. These steps are illustrated in Figure 2. Before a scientific paper is published, other researchers in the field assess whether it meets the rigorous standards of scientific literature, propose revisions or reject the paper. The reviewers must be impartial. They may not, for example, be based at same university as the authors. Common peer review methods are *blind review,* in which the reviewer's identity is not revealed to the author, and *double blind review* that implies that both authors and reviewers are anonymous. The reliability of the results increases, if other independent researchers are able to reproduce the original results.

Occasionally research results are proven false, or it is found out they do not hold true in all circumstances. We can, for example, claim that the boiling point of water is 100 ºC. This may seem true, until a mountaineer boils water at a lower temperature. The original statement has to be revised to take air pressure into consideration. Reproducibility is also essential in the field of technology, as, for example, a new device is used by many people in addition to the one who designed it.

In addition to evidence that supports your claims, you must look for alternative explanations and evidence that may refute your claims. If your research data is limited or your study is conducted over a short period of time, this may be problematic because specific variables (e.g. organizational restructuring seems to have improved the atmosphere in the workplace) cannot be isolated from other possible factors (increased order volume,

FIFA World Cup, etc.). A statement must be specified or omitted altogether, if alternative explanations or contrary evidence seem too probable and plausible.

Good scientific practice includes careful documentation, a logical approach and correct referencing style. It is perfectly acceptable to quote the work of others, as your references place your findings in the context of previous research and indicate that your research is well-founded. In addition, citations demonstrate that a specific statement was not made by you but someone else. Neglecting to acknowledge your original sources constitutes plagiarism. Broadly defined, academic misconduct occurs when the scientific community or decision-makers are misled. This includes presenting false data or results to the research community or spreading false data or results in a publication, in a presentation given in a scientific or scholarly meeting, in a manuscript that is intended to be published, in learning materials, or funding applications. In addition, misappropriating the work of other researchers and representing the work of other researchers as one's own constitutes misconduct. [11]

Research misconduct is divided into four subcategories [11]:

1. Fabrication occurs when a person reports invented observations to the research community. In other words, the observations have not been made using the methods presented in the research report or the research results are made-up. Intentionally presenting inaccurate findings or conclusions also constitutes fabrication.
2. Falsification and misrepresentation refer to modifying and presenting original observations deliberately so that the results based on those observations are distorted. The falsification of results refers to the unfounded modification or selection of research results. Falsification also refers to the omission of essential results or information.
3. Plagiarism, or unacknowledged borrowing, refers to representing another person's material as one's own without appropriate references. This includes research plans, manuscripts, articles, other texts or parts thereof, visual materials, and translations. Both direct copying and adapted copying constitute plagiarism. Self-plagiarism occurs when authors present as new and original their own previously published material.
4. Misappropriation refers to the unlawful presentation of another person's result, idea, plan, observation or data as one's own.

3. THESIS STRUCTURE

The logical structure of your text is the key to effective communication and dissemination of knowledge. The structure of a thesis is very similar to the structure of other scientific texts. A master's thesis typically includes the following chapters:

Title page
Abstract
Preface
Contents
List of abbreviations and symbols
1. Introduction
2. Theoretical background
3. Research methodology and materials
4. Results and analysis (possibly split into separate chapters)
5. Conclusions
References
Appendices (if applicable)

The titles of chapters from 1 to 5 are provided as examples only, and students are recommended to use titles that best describe the actual content. You can add more chapters and sub-chapters to your thesis, if necessary. You may start the chapters with a brief introduction, but then you must begin each chapter with a similar introduction. Each chapter may end with a brief summary or table that captures the main points.

The above structure is best suited for reporting the results of experimental research. The structure and content of your thesis may be different, if you are preparing, for example, a literature review or a design-oriented thesis. In such case, please consult your thesis supervisor or instructor for advice on the thesis structure before starting the writing process. For example, students majoring in information technology often write theses that are essentially planning and implementation projects. They replace Chapter 3 with a general description of the system and Chapter 4 with a more detailed description, results and analysis.

The average length of a bachelor's thesis is 18–28 pages and that of a master's thesis 55–75 pages. A licentiate thesis and doctoral dissertation may be 30–200 pages long.

3.1 Thesis title

The title of your thesis should be brief, accurate and catch the attention of the reader. If your thesis is written in Finnish, you must include the English-language title in the abstract page. Finnish students who write their thesis in English also need to include an abstract in Finnish. Avoid unnecessary abbreviations, company names and brand names. To make information retrieval easier, the title should contain keywords that best describe your thesis. Please note that if you include adjectives in your title – such as efficient, energy-efficient or fast – your claims must be carefully substantiated, for example, through measurements.

The student and the supervisor agree in a supervision contact on the responsibilities and rights of each party and the intended length fot the thesis project. The title of your thesis does not have to be the final one, but the title must clearly reflect the topic of your thesis will be about. It may be easier to complete the thesis before deciding on the exact title.

If you are writing a bachelor's thesis, you agree on the topic and title with your instructor.

3.2 Title page

The title page of your thesis features the University's logo, your name, the thesis title and type (bachelor's thesis, master's thesis or other written assignment). If the written report is a bachelor's thesis, master's thesis or a licentiate thesis, the day when the thesis has been submitted for evaluation is stated. The title page of written coursework also includes your student number and email address.

A template for the title page is available in Appendix 1.

3.3 Abstract

The abstract is a self-contained, concise description of the significance and content of your research. It must fit on one page. Finnish students include both a Finnish-language abstract (Appendix 2) and an English-language abstract (Appendix 3). International students only include an English language abstract. A bachelor's thesis includes only one abstract, which is written in the same language as the rest of the thesis.

The abstract describes your main research objectives, materials, key methods and results (numerical results are encouraged), conclusions and recommendations for further research. The abstract must be understandable even to people who are not familiar with the topic. Abstracts never contain information that is not mentioned in the main body of your thesis. Abstracts contain no references or quotations. Do not include charts or tables in the abstract, as they cannot be stored in publications repositories.

The following bibliographic information is placed at the top of the page:

Faculty
Given name Family name: Thesis title
Thesis type (Licenciate thesis, Master's Thesis, Bachelor's Thesis)
Month and year (when the thesis was submitted for review)

The actual abstract follows this information. The abstract and bibliographic information must fit on one page. The abstract is written using single line spacing and the same font as in the main body of the thesis. It is divided into paragraphs but no headings are used. In scientific papers the abstract is very short (typically 70–250 words) and only includes the key points: *what was the problem, what was done, what was the result.* It may make sense to write your conclusions, abstract and introduction last in this order by continuously distilling your message. This ensures that their content remains consistent.

Keywords: e.g. 3–5 keywords separated by commas are placed after the abstract text. Keywords are listed in order of importance; the most important keyword comes first.

3.4 Preface and contents

The preface contains general information about the thesis process. The preface includes a statement indicating the relative contributions of your instructor and possible other collaborators (instructions, advice and so on). If the research was undertaken by a group, the preface must detail the student's contribution to the research and the writing process. Acknowledgements to those who contributed to the thesis are generally presented in the preface. It is not appropriate to criticize anyone in the preface, even though the preface will not affect your grade. The preface must fit on one page. Add the date, after which you have not made any revisions to the text, at the end of the preface.

The table of contents starts on a new page. All headings following the table of contents, especially numbered headings, are included in it. However, the table of contents does not always include the headings that precede the table of contents. The headings that are included in the table of contents must be identical to the headings that appear in the text. Use your word processor's tools to generate and update your table of contents automatically. If you have to create your table of contents manually, try to achieve a similar end result as automated table of contents creators.

3.5 Abbreviations, symbols and list of figures

All the notations, symbols, units, abbreviations and terms used in your thesis are defined in this chapter. This chapter also begins on a new page. The exact title of this chapter depends on the type of abbreviations and symbols that it includes. Depending on the

nature of your thesis, this chapter may not even be needed. Each discipline has its own conventions for explaining abbreviations, so please consult your instructor and check what other students have done in their theses.

Abbreviations and symbols are grouped into categories and listed in alphabetical order. The explanation is tab indented. SI (Système international d'unités) units are not listed. Despite this list, any abbreviations and symbols are defined when they appear in the body of your thesis for the first time; the explanation is placed in parentheses. After this you can presume that your reader knows their meaning. If your thesis contains a large number of figures or tables, you must list them in appropriately titled chapters that start on a new page after the list of abbreviations and symbols. If your list only includes a few terms and looks like a stump, leave it out.

3.6 Introduction

An effective introduction catches your reader's attention, establishes the topic and prepares the reader for the content that follows. The introduction outlines the purpose and objectives of your research, in other words, the research questions that your thesis attempts to resolve and the methods to achieve that.

The introduction should contain short references to prior or contemporary research in your field to demonstrate that your work builds on existing research, even though previous research is discussed in more detail in later chapters. Placing your thesis in a theoretical context helps your readers understand the purpose and relevance of your research. If your thesis is part of a larger project, your independent contribution to the project must be clearly stated. A good choice is to list 2–4 most important things that you achieved through your research.

You can use a picture to describe the theme of your thesis to orientate the reader. The picture may, for example, portray the system that you investigated and the most important interfaces (input and output) and highlight your own contribution. Thus, the first picture included in your thesis familiarizes the reader with the topic of your thesis.

The introduction helps the reader form an overview of what to expect. This is why the introduction should briefly describe the content and structure of your thesis and specify how the different chapters are connected to each other. However, the introduction should not contain detailed descriptions of your research methodology, results, conclusions or recommendations for further research. The introduction is usually 2–4 pages long. It may be easiest to write it right after you have written the chapter titled Conclusions. Unlike in your conclusions, you cannot presume that the reader is familiar with the details or terminology, when you are writing the introduction. Your introduction should therefore focus

on key points: motivation (convince the reader why your research problem is important), your achievements, and the structure of your thesis (from the next chapter onwards).

3.7 Theoretical background, problem-setting or literature review

This chapter presents the technical, theoretical and other background information that is necessary in order for the reader to understand the research problems described later on in the thesis. Sometimes the research methods are also described in this chapter. The content of this chapter depends of your research field and the type of research. It is important that you describe your research problems and their importance clearly, so that readers understand what you are trying to achieve and what kind of criteria may be applied to evaluate to quality of your solution. As self-evident as this may seem, surprisingly many scientific papers lack a clear definition of the research problem and therefore leave the reader wondering about the rationale for carrying out the research project. You should replace the tentative heading provided above (”problem-setting”) with a more exact heading.

It is important that all concepts are carefully defined in the theoretical section of your thesis, so that readers know what you are referring to. A thorough literature review is necessary because a full understanding of relevant background information helps you avoid obvious pitfalls and stops you from re-inventing the wheel. The theoretical section must form a coherent whole with the entire thesis. Use clear language and delete irrelevant information. When you mention a term or something new, it is often enough to explain it in a few words and include a reference. You can assume that your reader is an expert in the field of engineering but has no specialized knowledge of the topic that you are discussing. A few carefully selected keywords may go a long way, but it is not necessary to present very basic information concerning your field.

Your background information may also include, among others, a description of the existing products of the company that commissioned your thesis, the system to be replaced, the standards to be followed, the internal practices of the company, and possible other parts of the project of which your thesis forms a part. This information must be presented in as much detail as necessary for you to lay out the rationale behind your choices and for your readers to form an overall picture of your research. Remember that you need permission to include any internal information on a company in your thesis. Figure 3 serves as a simple example of how you can present the topic and purpose of a design project. The reader can instantly see what the topic is and how it connects to a broader system. Some smaller details could still be added to it, such as the names of communication protocols, average data speed and the size of a database.

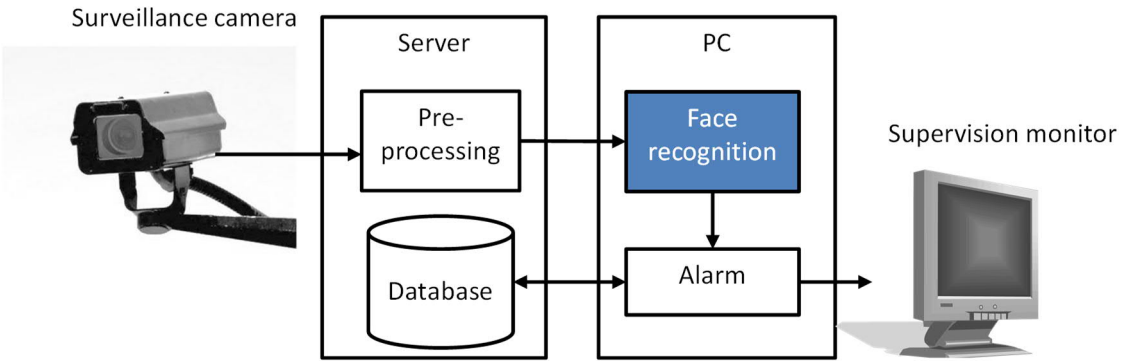

Figure 3. *The objectives of a fictional research project and an MSc student's contribution to the project. The topic of the student's thesis, i.e. facial recognition, is highlighted.*

The final structure and headings (including the main heading) of this chapter are determined based on the content and nature of your thesis (e.g. implementation project, experimental research or literature review). You can also divide this chapter into a number of subchapters. For example, the bachelor's theses prepared by students in the Degree Programme in Industrial Management are literature reviews, so the chapters following the Introduction are all based on previous research and titled to reflect the content. In case a chapter deals with multiple similar research projects (such as 6 different microprocessors), you need to make the reader's job easier by including a summary (e.g. a table) at the end.

3.8 Research methodology and materials

Your choice of research method depends on your research questions. The purpose of the methodology chapter is to provide the reader with a clear understanding of the research methods that you used to arrive at your results. This helps the reader assess the reliability of your findings. You can start by presenting alternative research methods and giving your reasons for choosing one method over the others. You must present your research materials in detail, so that there can be no confusion as to their origin and nature. It may sometimes be necessary to present a new hypothesis or theory before moving on to describe your research methodology or materials: if you measure something, it is important to know what you are measuring. This mainly applies to some dissertations.

You need to describe your research methods so carefully that other researchers in your field could reproduce your study and draw similar conclusions. This is the key principle of all scientific research [2], and it also applies to technical reports in general. For example, the mathematical basis of any new results must be presented in such detail that the readers can follow your train of thought without making long calculations of their own. At best, the source materials, such as measurement results and source codes, are openly

available in the public domain. If your thesis is a design or construction project, this chapter usually provides a general introduction to the system. Qualitative research methods must also be described as clearly as possible, even though the degree of reproducibility differs from quantitative studies.

A brief reference is enough, if the research method you are referring to is generally known within your field. More unusual methods, particularly ones that you have developed yourself, must be described more thoroughly. There must always be a clear connection between the preceding chapter discussing your theoretical background and your research methods and materials. You must clearly demonstrate the novelty of your research. You can devote multiple chapters to the discussion of your methodology and materials, if necessary. The final structure and headings are determined based on the content of your thesis. A good heading captures the essence of the chapter and is not nondescript like the headings 2–4 listed at the beginning of this chapter. However, your readers will be expecting to find chapters titled Introduction and Conclusions, so please use these headings even though they are somewhat bland.

3.9 Results and discussion

The purpose of this chapter (or chapters) is to discuss your research results and their relevance. The chapter presents your most important results, possible sources of error and deviations from the expected results and discusses the reliability of your research. This chapter must be at least partially self-contained, meaning that readers must be able to understand your results without carefully reading through the rest of the thesis. If you thesis involves a planning or construction project, this section presents first the details of your solution and then the results, possibly in separate chapters.

The results must be described briefly and accurately. It is a good idea to use figures and tables to illustrate your findings. Figures and tables serve an additional purpose, as they pique the interest of potential readers. You can present additional information in appendices, if necessary. Graphs are ideal for presenting trends, correlations and deviations, whereas tables are best used to present numerical data and lists. Numerical data increases the reliability of your research. Do not rely on your results to speak for themselves, as you must clearly demonstrate the value of your thesis.

Depending on your field of research, you can discuss your findings in this chapter or the chapter titled Conclusions. You compare your results to previous studies in the same field, which you described in the previous chapters. A careful discussion and analysis of your results improves the quality of your work compared to a simple list of findings. Tables sum up the details for easy comparison but their content must still be described in

the narrative: What are the similarities? What are the main differences? What are the deficiencies? What is the most popular approach? What is the recommended approach? Can trends be identified? You also need to assess the validity and reliability of your results, discuss whether the results correspond to your objectives and whether you succeeded in answering your research questions. The methods for assessing the reliability of your results depend on whether you conducted a quantitative or qualitative study. Reliability may also be discussed in the Conclusions chapter. Be sure to especially emphasize new or otherwise significant knowledge produced by your research. In addition, you need to reflect on the scientific and practical importance of your results. This chapter is your chance to shine and stand out. Here you can reap the fruits of your labour by being fair, precise and objective. Do not use empty marketing jargon in this or any other part of your thesis.

3.10 Conclusions

This is the most important chapter in the entire thesis. Many readers flip through the thesis, reading only the introduction and conclusions and taking a quick look at the figures and tables. Again, do not rely on your results to speak for themselves, as you must clearly demonstrate the value of your thesis. Instead of repeating individual research results in this chapter, sum up the main results and discuss their importance. A few of your most important numerical results should be repeated in this chapter. Especially in the fields of industrial management and information and knowledge management, it is typical that the results are interpreted and compared to previous findings in this chapter.

Based on your research results, you ought to present concrete measures that should be taken, give recommendations for the practical application of your results, and assess potential limitations to their use. Your recommendations may be intended for the company that commissioned your thesis, other researchers in your field or society as a whole. You should also assess the need for further research and the quality of your thesis. Conclusions usually take 2–4 pages.

A quick glance at the summary table provides an overview of the most important points. Table 1 shows an example of such a table [21]. The research objective, basic methods, strengths, weaknesses, workload and costs are briefly listed in the table.

Table 1. *Example of a summary table, adapted from an original source [21].*

Topic	Prototype of automatic bicycle gear-shifting system
Adjusted variable	Rear derailleur
Measured variable	Rotational speed of the rear wheel
Electronics	8 components, incl. microcontroller, servomotor and reed relay.
Microcontroller	PIC18.1 MHz, 1 AD converter, 4 timers…
Software	C, approx. 800 lines, memory usage 1.5 KB + 1 KB
Strengths	City and road use
Weaknesses	Off-road
Time spent	Planning 40 hours, installation 30 hours…total 190 hours
Equipment costs	Servomotor EUR 17, microcontroller EUR 12, others EUR 10.…

3.11 References

Your bibliography, or list of references, provides an overview of the theoretical and empirical context of your research and enables your reader to find further sources of related information. It must include all the bibliographic information needed to identify and locate the publication. Only the publications referred to in the body of your thesis are listed in your bibliography.

There are several different conventions for creating the bibliography and in-text citations. However, the bibliography must always include all the key bibliographic information concerning the publication, regardless of the referencing style that you are using. Make sure you follow the same style consistently throughout your thesis.

The title of the bibliography is ‘References’. The list is justified and written using the same spacing and font type as the body of the thesis. Leave a larger space or a blank line between each entry. The list begins on a new page and must be compiled in accordance with the referencing style that you have used throughout your thesis. For more information, please see Chapter 5.

3.12 Appendices

Your thesis may include appendices that contain materials that are necessary for the thesis as a whole, but do not constitute a core part of the thesis or cannot be included in the body text due to their awkward size or format. All appendices must be referred to in

the body text. Before appending any materials, consider if they really are necessary. Not all theses need to include appendices. Readers may browse through the appendices without reading the rest of your thesis, so it is advisable to include a heading and a short description at the beginning of each appendix.

You can append to your thesis, for example, lengthy mathematical derivations, an important algorithm in a programming language, input and output listings, an extract of a standard relating to your thesis, a user manual, empirical knowledge produced while preparing the thesis, the results of a survey, lists, pictures, drawings, maps, complex charts (conceptual schema, circuit diagrams, structure charts) and so on. In addition, detailed reports concerning measurements and other experiments should generally be presented in an appendix.

4. WRITING STYLE

Effective written communication requires both sound content and clear style. Keep the layout of your thesis neat and presentable and pay attention to your writing style in order to portray a professional image. This chapter focuses on writing style and formatting requirements that theses must comply with. In this guide, writing style encompasses not only text but also figures, tables, lists and mathematical notations.

4.1 Text

Always think of your reader when you are writing. This ensures that your text proceeds logically from general to specific, all terms are clearly defined, you show how your research builds on previous work and your main points are highlighted. The communicative purpose of the text determines what kind of information is included, what is emphasized and how you communicate your message to the target audience.

You need to provide cues that help your readers navigate your text and follow your train of thought. Guide your readers through your writing: first you let them know what to expect, then you make your points and end by summing up the key points. Move from general cases to specific cases, details and exceptions. Most of your readers will start by flipping through your thesis to get a general sense of your work. You should do the same to see what impression you get by only looking at the headings, figures and tables. Highlight your key points, for example, by discussing them in separate chapters or presenting them in a table or figure. The number of pages that you devote to discussing specific points indicates how important they are.

Avoid long sentences and complex sentence structures. A full stop is the best way to end a sentence. Use active verbs to make a dynamic impression. You should avoid the first person pronoun “I”, except in your preface. Even if you carry out the research independently, the stages of the research process are often described using some other sentence structure, such as “*this stage included…”.* You can also use the pronoun “we” (“*next we…”*), or the passive voice (“*…the stage was completed…”).*

Use established terminology and neutral language. The most important terms, reserved words and foreign word should be highlighted, at least when they first appear in the text. Use *italics*, **boldface**, or <u>underlining</u> (in this order of preference) for emphasis, but don’t overdo it.

Do not make overly complicated statements. Instead of writing, for example, “the identification and detection of the original author or group of authors who prepared the document or other equivalent material that served as a source for this piece of text”, write

"plagiarism detection", if that is what you mean. Avoid jargon, wordiness and circumlocutions. Instead of "The planning of the circuit board was accomplished in collaboration with the customer company", write "The circuit board was designed together with the customer company".

4.1.1 Argumentation

It is a good idea to begin the chapter by summing up the points that your readers are already familiar with before moving on to new things to ease your reader into the topic. After you have made new points, you can summarize the main ideas so that readers can follow your argument and understand your conclusions. You begin with a premise, or facts that your argument takes for granted, and follow the principles of correct reasoning to come to a conclusion, such as "*The argument A is true and therefore B must be true and C must be false*." Conflicting statements must be deleted or rephrased. There is a conflict, if a statement must be false for another statement to be true, such as "*We prefer freedom of choice… participation in x is mandatory*." Some of the examples below have been retrieved from [3][20].

If a premise is false, a valid logical argument may still lead to a false conclusion. Be careful not to draw too general conclusions based on limited observations. Example: "*As I have seen only black dogs today (premise), all dogs must be black (conclusion).* It is easy to refute this argument by naming even a single dog that is not black. Please note that "always" and "never" statements are especially problematic.

Terms must be unambiguously defined to avoid meaningless statements. You should ask yourself how a term is measured and what its defining features are. How do you measure efficiency, pleasantness, or equality? Example: "*I predict that if the markets respond favourably, the stocks of company Y will go up by 2%."* The problem with this statement is that the favourable response of the markets is not adequately defined. The prediction is accurate, if the stocks go up by 2% and in any other cases the markets did not respond favourably, so the high-priced analyst is always right. Changing the term or inventing a new one will not change reality; "*blundering*" is what it is even if you call it "*a process optimized by a committee*".

You need strong evidence to make causal claims. A classic example is the following statement: "*Statistics indicate that as ice cream sales go up, the rate of drowning deaths increases sharply. Thus, ice cream causes people to drown*", whereas in reality, people are more likely to eat ice cream and go swimming and sailing when the weather is hot.

An incident may be highly unlikely and yet accidental. You need to remember this when you consider why things or events occur. Let's assume that "*Pentti wins the lottery on Saturday. Winning the lottery is extremely unlikely (n. 1:15 000 000), it is even more*

unlikely to occur on a Saturday (n. 52:365) and even more unlikely to occur to Pentti (n. 1:5 388 000). This event is so unlikely that the lottery machine must have been tampered with." Had Pentti not won, we would not have given a second thought to the unlikelihood of this event. Of course the matter becomes more intriguing, if the same person wins the lottery multiple times or, for example, on a Thursday, when there is no lotto draw.

If you demonstrate that a statement is false, it does not automatically mean that the opposite statement is true. Both statements may very well be false. For example, the statement "*The Earth travels around the Sun in a circle.*" (Theory A) has been demonstrated to be false, but this says nothing about the validity of the statement "*The Earth travels around our political party*." (Theory B). Even though theory *A* is false, it is still closer to the truth than theory *B*, at least from the point of view of physics. This kind of faulty reasoning should be eradicated. The truth of a statement does not depend on who said it. Naturally the reputation of the person often plays a part in our estimation of the reliability of a statement, if there is no factual evidence one way or the other. Thus, you need to present evidence for your claims.

4.1.2 Comparison

Comparisons are essential to basic scientific inquiry. Comparisons must be accurate, especially if you are drawing causal claims. Contrary to an old saying, you can and should compare apples and oranges (in terms of, for example, size, weight, flavour, vitamin content, price, allergens). Of course, you have to make sure that all variables have been identically reported, such as whether the weight of oranges has been given with or without the peel. The most common problem with comparisons is that if multiple parameters change simultaneously, we cannot be sure which factor or factors have influenced our results.

Controlled experimental settings ensure that only one variable is tested at a time, so we can evaluate cause-and-effect relationships. If possible, you should aim to produce quantitative results rather than qualitative results in your thesis. If you have to take multiple criteria into account, it is often not enough to use qualitative analysis to draw conclusions. We can, for example, argue that Rolls-Royce is superior to a Toyota but more expensive. This is a qualitative claim. An empirical study reveals that there are not as many Rolls-Royces as Toyotas in Finland. If we compare the two models by stating that car *X* is 17.6 % better than car *Y* but 24 times more expensive, the reader can conclude that car *Y* is likely to be more popular. The term "superiority" and how it is measured must be very precisely defined on a case-by-case basis. If you are investigating two variables, a graph with an x-axis and a y-axis is often a good alternative for depicting the relationship between the variables.

4.1.3 Lists

Lists can make complex content easier to understand, but excessive use of lists should be avoided in formal writing. You should take at least the following four points into consideration:

1. The order of the items in a list must be carefully considered.
2. All items must have parallel structure.
3. The items in a list must be short and approximately of equal length.
4. A numbered list of often the clearest alternative.

The order in which information is presented influences the way that the reader understands the message. Thus, you need to consider the order of text, lists and tables carefully. Information may be presented in order of importance, chronological order, category-based order, order of superiority, order of size, and sometimes even alphabetical order. A numbered list is clearer than a bulleted one, if the number of items in your list is mentioned in the text or if you refer to the individual items in the text. Especially operating instructions must be given in sequential order. Lists must always be connected to the body text; they cannot stand alone.

4.1.4 Abbreviations

A large number of abbreviations are typically used in the fields of engineering, but you need to use them carefully. Do not overuse abbreviations. Common abbreviations (such as e.g., i.e., etc.) should mostly be written in their full form. Other abbreviations must be written out when they first appear in the text: SI system (French Système international d'unités). You should also indicate the language that the abbreviation is derived from, but you do not have to do this, if the text includes several abbreviations and they are all derived from English. Similar to symbols, you should explain abbreviations in plain language at least when they appear in the text for the first time. If you keep referring to the concept, you can use either the abbreviation or the plain-language definition, as long as the meaning becomes clear. It is often best to use plain-language terms, as an excessive use of abbreviations and acronyms may make your text difficult to read.

The plain-language definition may also precede the abbreviation, as in "*The file system FAT32 supports…*". Use lower case and upper case letters consistently in abbreviations and acronyms. Some abbreviations have become so common that they are treated like regular words, such as LED, or light-emitting diode.

4.2 Figures

Vision is the most important sense we have. Done right, a picture is an efficient and lucid method for presenting large amounts of data and helping your readers focus on important content. Reading, on the other hand, is a sequential process in the brain and therefore takes more time and effort.

Figures may be, among others, drawings, photographs, charts or maps. You can also present lists, algorithms and program code as figures. You must refer to all the figures in

the body text. The reference should preferably appear on the same page as the actual figure or before it. Rather than provide detailed information, a figure, such as a screenshot, may occasionally be included to give a specific impression to the reader. For instance, the first figure in your thesis should introduce your topic without overwhelming readers with too much detail. Please see [13] for further recommendations.

All figures must be explained in the body text, so that readers know what they are supposed to notice. Some numbers and terms displayed in a figure or table should be mentioned in the text, so that the connection between the text and figure/table becomes obvious. Example: *"Figure 4 demonstrates that the time of flight is 3.8–6.3 seconds (variation is approximately 1.65x) and height is 16–55 m (up to 3.4x variation), depending on the angle of departure. The angle α has a significant impact, as an increase of 10 degrees increases the highest point of the trajectory by some 10 m. The shape of the diagrams…"*.

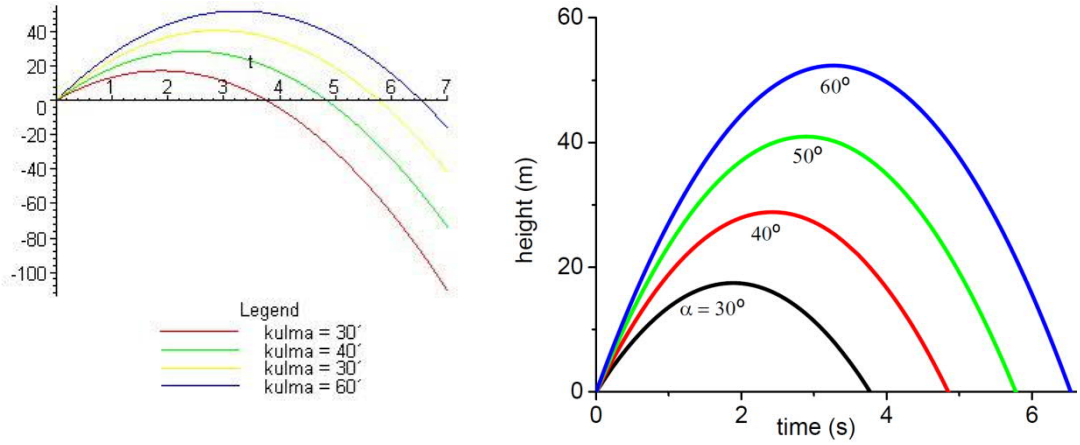

Figure 4. *Diagrams should be edited before publication. The diagram on the right is an edited version of the one on the left.*

Figures generated by analysis software usually need further editing. Unnecessary elements must be removed, line widths need to be adjusted and text locations defined. Diagrams must always be edited before publication. An example of an unedited and edited diagram is presented in Figure 4. The unedited version is on the left and the edited version on the right. Unnecessary negative values along the y axis have been removed, both axes have been named, the description of each line has been moved next to the lines, and the values have been spaced out (4 m vs. 10 m). Any text included in the figures must be readable. The recommended font size is the same as that of the body text but no smaller than 10 pt. If possible, any text included in the figures should be written in the same language as the rest of your thesis (note that the unedited example figure is in Finnish).

If your graph includes a horizontal axis and a vertical axis, the scales are shown on the axes to indicate exactly what is being measured and the units of measurement used.

The scale generally begins at zero. This allows your reader to easily interpret the relations in data (half, equal, double, and so on). If you use a logarithmic scale, you can add a further description next to the axis, such as "*Frequency (log), [Hz]*".

Figures must be drawn up following the standard drawing methods (for example, those concerning circuit diagrams) and they must be used consistently throughout the thesis. Instructions for citing a figure prepared by someone else are included in Chapter 5.

You may use coloured images and photographs in your thesis, but any text that appears in a figure should be black. The figures must be readable, even if your thesis is printed in greyscale. Photos and graphs should be accompanied by text boxes, arrows and a scale indicator. Flowcharts go from left to right and from top to bottom. The initial data and results must be clearly described. Small, icon-like pictures increase information intake and retention (please see, for example,Figure 1).

Figures and tables must be consecutively numbered (as in this guide) throughout your thesis, so that both follow separate numbering systems. Figures should primarily be placed at the top of the page, but you are free to decide where they fit best. You can rotate a wide figure or table 90 degrees, so that it fits better on the page. It is not recommended to place several full-page figures one after the other. You can place figures in appendices, if necessary.

Figures and the caption are either consistently centered or aligned to the left. The caption is placed under the figure and always on the same page as the figure. The font type and size of the caption are the same as those of the body text, but the caption is written in italics and with single spacing. The caption should indicate what the reader is supposed to notice when looking at the figure, even though the same information is provided in the body text. Never start a chapter with a figure, table or list.

4.3 Tables

Tables are inserted into the body text or placed in appendices. Tables are consecutively numbered and captioned, as in Table 2. The caption is placed on the same page but above the table, unlike the captions that accompany figures. Variables, abbreviations and symbols that appear in the table are defined in the body text, if necessary. You must refer to all the tables in the body text, even if their relevance to the thesis seems obvious. Try to prevent the table from splitting into separate pages.

Table 2. *Example of evaporation conditions in a thin film structure.*

Substance	Thick-ness	Correction coefficient	Pressure (mbar)	Tempera-ture (°C)	Current (mA)	Speed (nm/s)
SiO_2	181.0	1.10	$3.0 \cdot 10^{-5}$	90.6	20−23	0.2
TiO_2	122.1	1.55	$15.0 \cdot 10^{-5}$	91.1	100−93	0.1

In addition, you must discuss the content of any tables in the body text to ensure that readers understand their relevance. For example "*Evaporation conditions of SiO_2 and TiO_2 thin film structures are compared in Table 2. We notice that the biggest differences can be found from the evaporation current and the growth pressure. The growth pressure is nearly 5 times bigger forTiO2. The main reason for this is oxygen, which is added to the chamber to stabilize the refractive index of the thin film. Evaporation current is more than 4 times bigger which is mainly explained by the differences in the evaporation temperatures."* It is also ok to use format 5x, like in the figure example.

Tables allow you to display large amounts of numerical data in an accessible and concise format. Tables make it easy to spot missing values (and sometimes divergent values). It is a good idea to sum up your background information and your own research in a table. You can replace a large numerical table with a line or bar graph to organize the information and make it easy for your readers to understand. Your tables may also include statistical values, such as minimum, maximum and average values.

Mark the titles of the columns and units clearly. You can use boldface to highlight the titles and use a double horizontal line to separate them from the rest of the table. The order of the columns and rows must be carefully considered. An alphabetical order, although better than a random order, is rarely an especially good choice. Instead, you can order the rows first based on type (such as domestic companies at the top and international companies at the bottom) and then based on the most important value (such as annual turnover). As few as 2–3 categories can significantly increase the readability of your table. The same applies to columns.

Do not surround all the cells with a border, as it may make your table harder to read. Put a line on top and bottom of the table. You can add a horizontal line between every 4–5 rows, if the data is not grouped into categories. If the table is large, the rows should be numbered if you plan to refer to the rows in the body text. If the purpose of your table is to compare values, the highest (or lowest) value in each column or row should be highlighted. The numbers are right aligned (optimally lined up at the decimal point) for easy comparison. For the same reason, the pressure of titanium oxide is presented in Table 2 as $15.0 \cdot 10^{-5}$ and not as $1.5 \cdot 10^{-4}$. You should preferably use SI units, established prefixes (such as milli (m), micro (µ), nano (n)) and rewrite large numbers as powers of ten.

The power of ten should be placed in the title of the column instead of using a different power of ten on each row, if possible. More information on using tables can be found in [13].

4.4 Mathematical notations

Mathematical notations allow you to express concepts briefly and unambiguously. A simple example is provided by comparing two variables. If you say that variable *B* is three times larger than *A*, your statement is ambiguous and therefore wrong. Your readers will interpret your statement differently, either as $B = 3A$ or as $B = 4A$. When the statement is written in the language of mathematics, it is both shorter and clearer.

4.4.1 Numbers and units of measurement

The way that numerical values are written depends on the text type. In literary texts, numbers are generally spelled out. In statistics and technical writing, numbers are generally written using numerals for the sake of clarity [16]. In your thesis, it is therefore better to write "*6 stages*" than "*six stages*", which is nevertheless strongly preferred to "*a couple of stages*". You may, however, spell out numbers from 1 to 10 as well as large round numbers, such as hundred, thousand and million. There are many advantages to using numerals. They are shorter and easier to read, and this becomes especially important if your reader is flipping through the pages or looking for exact numerical values. For instance, it is much easier to spot 5.5 than five and a half on a page. For easier readability, you should also use a thousand separators (write 55 700 125 instead of 55700125). Never omit the leading zero in decimals. For example, it is correct to write "0.5" and wrong to write ".5". A comma is used as a decimal separator in the Finnish language and a period in the English language.

Like numbers, it is advisable to abbreviate units of measurement. It is better to write 3 m, 100 Hz, 25 % and 120.4 kg than three meters, one hundred hertz, twenty-five per cent, let alone one hundred and twenty kilograms and four hundred grams. There is a space between the number and the unit, but you should keep them on the same line[1]. It is better to compile a table or graph than include a great deal of numerical values in the body text. Use precise language and put numbers on a scale. For example, the phrase "*centrifuges that are cost-effective [1,2,3] and optimized for speed [4,5]*" should be rephrased for clarity as follows: "*…affordable (EUR 200–400, less than 4,000 rpm) [1,2 3] and fast (over EUR 900 EUR, over 10,000 rpm) centrifuges...*"

[1] In LaTeX, you can do this by replacing a space with the character "~". In Word, you can use the non-breaking space symbol.

4.4.2 Equations

Newton's Second Law can be presented in the following way:

$$ma = F, \tag{1}$$

where *m* denotes the mass of an object, *a* means acceleration, and *F* means force. Please note that all the variables must be defined at the point of their first appearance in your thesis.

You should preferably use generally known and well defined concepts and standard conventions and symbols for representing them. Avoid using too many concepts and notations that you have invented yourself. New concepts should be defined when they appear in the text for the first time. Upper case and lower case letters mean different things in symbols and units of measurement.

Do not use the same symbol to mean different things. Concepts and notations that you have invented yourself must be used sparingly. It is often easier to use the letters of the Latin alphabet to denote your own variables than Greek letters, especially in diagrams and pictures. Units of measurement must be clearly marked. Depending on the context, the length *L* may refer to, for example, metres, yards, seconds or even the number of letters, words or pages. You must specify whether bigger is better or smaller is better, especially if you are using different quality or index values, such as price index, benchmark result or priority. All ratios must be explicitly defined; for example, "*the ratio of A to B*" can be understood in two ways, whereas "*let us determine the ratio r = A/B*" is unambiguous.

Mathematical formulas are numbered, if they are written on separate lines and referred to in the main body of the text. The number is usually put in parenthesis and right aligned, as in this guide. In the English-speaking world, formulas and equations need to be contained in complete sentences with proper punctuations, as in the equation (1) above. If you are writing your thesis in Finnish, it is acceptable to leave out the period or comma following equations. Occasionally mathematical notations are preceded by an identifier, such as Definition 1 or Theorem 1. Similar to figures and tables, mathematical formulas may be numbered sequentially throughout the whole thesis or sequentially per chapter, either as (1), (2)… or (1.1), (1.2),…, (2.1),…. Simple formulas may be displayed within the body of the text without numbering.

Do not start a sentence with a mathematical symbol. Add some word, such as the name or type of the symbol, in front of mathematical symbols. While the second sentence below is grammatically correct, it looks strange:

> … in which *F* stands for force. *a* is a real number that represents acceleration.

Instead, you should write, for example:

> … in which *F* stands for force. Acceleration *a* is a real number...

Your thesis should flow smoothly, even if it contains a great deal of symbols, formulas and equations. The sentences must be grammatically correct. One of the most common mistakes is to replace the predicate with the symbol "=" in the body text. All sentences end with a punctuation mark, and the main elements of a sentence are separated by a comma in accordance with the rules of English grammar.

Variables, such as *x* and *y*, are generally presented in italics, whereas elementary functions, special functions and operators are not:

$\sin(2x+y)$, grad T, div B, $\lim (x^2 - 1)/(x + 1)$.

This convention helps the reader distinguish, for example, the possible variables *s*, *i* and *n* from the trigonometric function sin.

Logarithms must always be written with base, i.e. log2(*x*), $\log_{20}()$, $\log_a()$, with the exception of the natural logarithm ln(). In principle, the notation lg() can be used for base 10 logarithms, but unfortunately this may lead to confusion since some authors have used it for binary logarithm.

Various conventions are used to distinguish vectors from operators (matrices), such as:

1. Operator appears in boldface: **L**u = v.
2. Operator appears in boldface, vectors are underlined: **L**$\underline{\text{u}}$ = $\underline{\text{v}}$.
3. Operator is bold and upper case, vectors are bold and lower case, scalar variable appears in regular font: **Lu** = a**v.**

Functions and their values should be distinguished in mathematical writing. For example, function *f* maps elements of a set *X* to set *Y*. Thus, $f(x) \in Y$ is the value of the function *f* at argument $x \in X$. Use parentheses to group together parts of the equation and add clarity: does $\sin x^2 + y^2$ mean $\sin(x^2 + y^2)$, $y^2 + \sin(x^2)$ or perhaps $y^2 + (\sin(x))^2$?

The mathematical writing style that you should use in your thesis depends on the context. A written description without the formula is often too ambiguous. You may have to make compromises between logical clarity and readability. LaTex uses *italics* for variables automatically in the math mode to make them stand out [10].

4.5 Programs and algorithms

You may need to present algorithms in the form of pseudocode or actual or program codes. Often they can make the procedures and stuctures easy for your reader to understand. In a thesis, codes and algorithms are written using monospaced font, such as Courier New, Consolas or their variations (for example LaTeX has so called teletype).

If the length of the code or algorithm is less than 10 lines and you do not refer to it later on in the text, you can present it similarly to formulas:

```
{
       cout << "Pay attention.."       << endl;
       cout << "..or else!" << endl;
       return EXIT_SUCCESS;
}
```

If the code is longer but shorter than a page, you present like a figure (like Program 1) titled “Program” or “Algorithm”. The numbering follows the same conventions as figures. Codes and algorithms that exceed one page in length are presented in appendices.

Identifiers, such as variables and class names, are written in *italics* in the body text and just like any other words in program codes. They must be written in the same way as in the program. Do not begin a sentence with the name of a variable. Another alternative is to use the same font as in the code: “return value `EXIT_SUCCESS` denotes…”.

```
void sort( charPair arr[], int size )
{

  // Sort a table so that each round looks up the smallest re-
maining
  // letter and moves it to correct location.
  for( int i = 0; i < size; ++i )
  {
    // Find the smallest, i.e. closest to letter ‘a’
    int idxSmallest = i;
    for( int j = i; j < size; ++j )
    {
      if( arr[ j ].replacable
          < arr[ idxSmallest ].replacable  )
      {
         idxSmallest = j;
      }
    }
    // Move the smallest item to its correct location
    charPair tmp       = arr[ i ];
    arr[ i ]           = arr[ idxSmallest ];
    arr[ idxSmallest ] = tmp;
  }
  return;
}
```

Program 1. *Example of presenting program code as a figure in a thesis.*

Reserved words, such as for, if and return, are preferably presented in **boldface** in program codes but not in the body text. You may occasionally replace the parameters of complex functions with three dots, such as *foobar(…),* for the sake of simplicity.

You should add some comments to the code and indent it consistently. The actions performed by the code must be outlined in broad terms in the body text. Line numbers make it much easier to refer to the code in the text. For example, the *listings* package for LaTex [6][10] is a tool for typesetting source code and pseudocode and highlighting reserved words.

5. REFERENCING STYLES

Good scientific practice requires that any research, words or ideas that are not your own are clearly and consistently cited. Citing a source means that you acknowledge and give credit (and place the primary responsibility for the accuracy of the content) to the original author. Taking credit for other people's work is a serious mistake. Citations and references are especially used when you describe your theoretical framework and compare your results with those of others.

Different referencing styles determine how you create 1) **in-text citations** and 2) **the bibliography**. In-text citations are placed within the body of the text and they refer to the references listed at the end of your thesis. The bibliography provides detailed information on the source and must enable anyone reading your thesis to locate the original source.

5.1 Use of references in a thesis

University students are expected to utilize and apply previously produced scientific knowledge in their own work. Your references demonstrate your familiarity with the topic and enable the examiner to form an overall picture of the quality and reliability of your thesis. In addition, your references indicate how well you know the most important publications and researchers in your field.

You use knowledge produced by others to justify your own results and compare different research results. A reference demonstrates that someone else agrees with your statement and that the claims you make are not unfounded. However, all sources of information are not equally reliable. You are responsible for assessing the quality and reliability of your sources by considering, for example, the following points: author, publisher, references used by the author and accuracy of the provided information.

Please use discretion when referring to electronic materials found online, especially if the publisher is unknown. For example, online forums may often be an unreliable source of information. You can use some online materials, such as standards and company websites, with discretion. Wikipedia should not be cited as a source in an academic paper, even though it may be helpful when you first start gathering information for your thesis.

5.2 Numeric and name-year systems

Two common referencing styles are presented in this chapter:

1. Numeric referencing (Vancouver system), such as [1],[2]…
2. Name-year system (Harvard system), such as (Weber 2001), (Kaunisto 2003)…

In the Vancouver system, a running number is allocated to your sources and you insert the number into your text in square brackets []. In the Harvard system, the last name of the author and the year of publication are given in round brackets ().

Both styles are acceptable, but the conventions for referencing vary between disciplines. Please consult your instructor and check which style other authors in your field have used. The Vancouver style of referencing is popular in the fields of engineering, for example, in IEEE's database that contains more than 3 000 000 publications [7]. The Harvard system is commonly used in the fields of industrial management, information and knowledge management, and architecture.

The numeric style is economical, but the numbers are meaningless without recourse to the bibliography. However, it is easy to mention the author (and year) in the text, if necessary: "*Weber stated already in 2001 that… [1].*" The name-year style takes up more space and includes more exceptions, but makes it easier to add or subtract in-text citations and references manually. Both systems have pros and cons, but you must pick one and use is consistently throughout your thesis.

5.3 In-text citations

In-text citations are placed within the body of the text as close to the actual citation as possible. The citation is generally placed within the sentence before the full stop.

The place where the citation is inserted basically tells the reader the extent of the citation. In principle, if the cited section is longer than one sentence, the in-text citation may be placed at the end of the final sentence after the full stop, for example, like this: "*It is important to optimize both the planning costs and production costs of microcircuits. One alternative is a reusable technology platform. [100]*" Thus, if the entire paragraph uses cited material from the same source, the citation may be placed at the end of the paragraph after the full stop. Unfortunately, this may be confusing to your readers. An alternative solution is to insert the citation right after the first sentence and rephrase the following sentences in a way that makes it clear that they all come from the same source.

The following paragraphs include examples of different types of citations. Examples are provided in both the Harvard and Vancouver styles of referencing, but please remember not to mix and match the two styles in your thesis.

Citing one source in one reference

Citing one source is the most common type of citation. You should also provide the page number(s) in the in-text citation, if the reference is to a specific section in the original source. You can leave out the page number if you are citing the entire work.

In-text citations may be used to replace some elements of a sentence. A numeric reference may replace the name of the original source but should not begin a sentence. The name-year reference may replace the author's name. If the publication has more than two authors, you only mention the first author and replace the others with the abbreviation *et al*. However, all the authors are always listed in the bibliography. (The italics are only used here to indicate a foreign word; et al. need not be italicized in your thesis.)

Weber argues that … [1].

Cattaneo *et al.* introduce in their study [2] a new…

The result is … [1, p. 23]. One must also note… [1, s. 33–36]

In accordance with the presented theory … (Weber 2001).

It must especially be noted… (Cattaneo *et al.*).

Weber (2001, p. 230) has stated…

Citing multiple sources in one reference

If you are referring to multiple sources at the same time, all the sources can be collected in one citation. If you use the numeric system, the numbers are listed in ascending order. If you use the name-year system, you order the works by the year of publication. You can use a hyphen to join inclusive numbers.

Based on literature in the field [1,3,5]…

Based on literature in the field [1][3][5]…

The topic has been widely studied [6–18]…

…existing literature (Weber 2001; Kaunisto 2003; Cattaneo et al. 2004) has …

The above examples illustrate the major difference between the two referencing styles. Be careful not to let long lists of names and years obscure your main message.

Citing a figure taken from another source

If a table or figure is cited from another volume, the in-text citation is placed in the caption or the heading of the table. The full reference is listed at the end of your thesis. Only a numeric citation is given in Figure 5 to save space. If you edit a figure or table taken from another source, for example, to ensure that colours, terms and notations match the rest of your thesis, you add "*adapted from [15]*" to the citation.

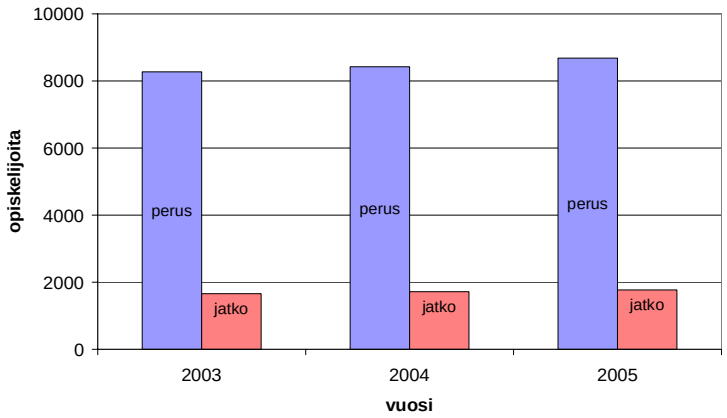

Figure 5. *Number of students enrolled as attending at TUT in 2003–2005 [15].*

Direct quotation

Direct quotations are rarely used in scientific papers in the fields of engineering. If you use direct quotations, you put the exact words of another author or source inside quotation marks. The period comes before the final quotation mark, and the direct quotation is followed by the reference.

”Research is carried out in accordance with the principles of academic integrity, namely honesty and the responsible and ethical conduct regarding research and presentation and evaluation of the results.” [7, p. 3]

”Research is carried out in accordance with the principles of … honesty and the responsible and ethical conduct regarding research and presentation and evaluation of the results.” (Finnish Advisory Board on Research Integrity 2012, p. 3)

The second sentence is also an example of a source with no known author. The long quote has been shortened, and the removed section is indicated by substituting a sequence of three dots. You can use brackets to add information to a quoted sentence to make the sentence read more clearly or add a correction or comment.

”This [academic misconduct] includes presenting false data or results to the research community or spreading false data or results in a publication, in a presentation given in a scientific publication…” [5]

Your sources may occasionally include misspellings or other errors. You can use “sic” (Latin word for thus) to indicate that the error was found in the quoted source.

”There are some convenient alternatives for the MS Wrod (sic).” (Salminen 2014, p. 36)

Secondary sources

You should always strive to use original (primary) sources instead of secondary sources that cite the results of others. You should always try to locate the original source cited in a secondary source, but it is not always possible. The original work may be unavailable,

illegible or contain errors that have been corrected in a secondary source, such as a textbook.

If you use a secondary source, the in-text citation must clearly indicate that the information comes from a secondary source. In the following example, the primary source is the book *Shleinen et al., Handbook of Health Physics and Radiological Health*. The author is, however, referring to the book *Pöllänen, R. (ed.), Säteily ympäristössä*, in which the original table is translated to Finnish. The original source is included in your bibliography only, if you have read the original source. The reference is presented in the body of the thesis as follows:

The mass attenuation constant 1.0 MeV for photon in aluminium is 0.0615 cm2/g [1, see 2].

According to Shleinen et al. [1], as cited in Pöllänen [2], the mass attenuation constant 1.0 MeV for photon in aluminium is 0,0615 cm2/g .

The mass attenuation constant 1.0 MeV for photon in aluminium is 0.0615 cm2/g (Shleinen et al. 1998, cited in Pöllänen 2003).

According to Shleinen et al. (1998) the mass attenuation constant 1.0 MeV for a photon in aluminium is 0.0615 cm2/g (see Pöllänen 2003).

Special cases of in-text citations when using the name-year system

If the author's name is mentioned in the sentence, the in-text citation may include just the year of publication.

…Cattaneo et al. (2004) claim…

If the author has produced several publications in the same year, you should differentiate them by adding a lower case letter directly after the year of publication. The same lower case letter is naturally included in your bibliography at the end of your thesis.

…based on the presented theory (Weber 2001a) …

If a publication has two authors, both must be mentioned in the in-text citation. If a publication has more than two authors, you only mention the first author and replace the others with the abbreviation "*et al*". When you refer to the source for the first time, you can also mention all the authors. All the authors are always mentioned in the bibliography.

…based on the presented theory (Smith & Braun 1994)…

It must especially be noted… (Cattaneo et al.).

If the author is unknown, a sufficient number of words from the beginning of the title are marked as the source, so that the reader can locate the corresponding entry in the bibliography.

…according to the manual (Raw Materials Manual 2002) the corrosion resistance of aluminium…

...according to the standard (SFS 5342 1992), references are used to…

The examples above are not special cases, if you are using the numeric Vancouver style of referencing.

5.4 Bibliography

The bibliography at the end of your thesis must provide full and accurate details of all the works that you have cited. The guidelines for formatting a bibliography are largely similar regardless of the type of your sources. First and foremost, your bibliography must be clear and consistent. The following subchapters describe how you should write bibliographic entries that refer to commonly used information sources, such as books, scientific papers, conference proceedings, reports and standards.

5.4.1 Order of bibliographic entries

Your references are listed at the end of your thesis in alphabetical order based on the first author's last name. If the author is unknown, alphabetize the source using the corporate author or title. There are no straightforward rules for alphabetizing last names that include a prefix. Simply put, prefixes written in lower case are ignored in alphabetizing, but prefixes written in upper case are not. For example, Edwin van der Sar is alphabetized under "S" and Robert De Niro under "D".

Some conference proceedings allow the references to be listed in the order they appear in the text. This style is only acceptable, if the author uses the numeric system and the list of references is relatively short.

5.4.2 Bibliographic information

All the references included in the body text must be followed up with full publication details, if they are known, as an alphabetical bibliography at the end of your thesis. The entries must include all the details listed in Table 3.

Table 3. *Necessary bibliographic information.*

#	**Numeric system**	#	**Name-year system**
1.	authors,	1.	authors,
		2.	(year of publication)
2.	title,	3.	title,

3. publisher, 4. year of publication, 5. pages, 6. URL, if applicable	4. publisher, 5. pages, 6. URL, if applicable

The numeric identifier and how to show the time of publication set the two referencing styles apart. The time of publication is usually the year. If you are using the name-year system, the year of publication is in parenthesis. Formatting examples of an journal article in bibliography are provided below, first in the numeric style and then the name-year style.

> [100] K. Keutzer, A.R. Newton, J.M. Rabaey, A. Sangiovanni-Vincentelli, System-level design: orthogonalization of concerns and platform-based design, IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems, Vol.19, No.12, Dec 2000, pp.1523–1543.
>
> Keutzer, K., Newton, A.R., Rabaey, J.M. & Sangiovanni-Vincentelli A. (2000). System-level design: orthogonalization of concerns and platform-based design. IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems. Vol.19(12), pp.1523–1543.

In the example above, there are 4 authors and the publisher is a journal that is part of IEEE Transactions. The volume (Vol 12) and issue (No. 12) indicate the time of publication, even though the volume is basically unnecessary information. If this information is not provided in the journal, they are, of course, left out. The publisher may also be a conference or a book publisher. Your readers will primarily focus on the publisher, when they assess the credibility of your sources. As it is crucial that your readers are able to easily locate your sources, you may include some additional information in your bibliography, such as the datasheet identifier. The URLs of online sources are subject to change and may become outdated, so your readers must be able to locate the source based on the other details that you have provided. This is why the citation must include the date when you accessed electronic materials. In addition, it is advisable to copy or print out any electronic materials that you have referred to in your thesis.

Below are 3 examples of name-year references. The name of the author may be written in capital letters to make it stand out. In the final example, an identifier (Keutzer 2000) is explicitly given in the bibliography, so readers can easily find the citations using their word processor’s search function; the remaining details may then be listed in the same order as in numeric references.

Keutzer K., Newton A.R. … (2000) System-level… pp.1523–1543.
KEUTZER K., Newton A.R. … (2000) System-level… pp.1523–1543.
(Keutzer 2000) K. Keutzer, … 2000, pp.1523–1543.

If the author is unknown, the reference begins with the title. The abbreviation Anon. (anonymous) is no longer used. You need to include the names of all the authors in the bibliography, even though only the first author is mentioned in the in-text citation. Write names consistently using the same style, for example, either “K. Keutzer” or ”Keutzer K.” The other bibliographic information is written in the original language (for example, “2nd ed.” in a Finnish-language thesis). This guide does not dictate whether all the words included in the English-language names of books and journals should be written in lower case or upper case. Even if there were a commonly used abbreviation available, the names of journals should usually be written in their full forms.

Convenient reference management software is available for formatting your bibliography, such as Bibtex [4] and RefWorks [19]. You need to type each reference only once, and the system constructs your bibliography automatically.

5.4.3 Examples of bibliographic entries

This chapter includes examples of constructing the most common types of bibliographic entries. The main aims are simplicity, consistency and minimal punctuation. There are close to 20 types of original sources that you can use in your thesis, but the type of source does not affect the order or formatting of your references. Please note that here the numbers assigned to different types of sources are written in *italics*, so readers do not mix them up with numeric references at the end of this guide. We begin by presenting the 8 most common types of sources: book *[1]*, journal article *[2, 3]*, article in a compilation *[4]*, conference proceedings *[5]*, thesis *[6]*, report *[7]* and datasheet *[8]*.

Please note that the sources are listed in the order they appear in this guide (the most commonly used sources are given first) and not in alphabetical order based on the author’s last name. The type of each source is also specified here, but it is not included in the bibliography of your thesis. To make the list more readable, more space is left between the entries, and entries that include multiple lines are indented. The references are consistent with the numeric style of referencing.

If the source is a book, the place of publication is indicated, if it is known, as in the example *[1]*. If multiple cities are listed on the book’s title page, include the first one in your bibliography. The publishing cycle of books is slower than that of journals, such as *[2,3]*. The abbreviation p. indicates the number of pages and pp. the page range. You may leave out the total number of pages, but it gives your reader an indication of the extent of the original source.

Conference proceedings are usually the fastest way to get new research results published. The article authored by Li et al. *[4]* has been published in a compilation, and the editor “H.S. Nalwa” is also mentioned. The example *[5]* includes comprehensive details

of the source, such as exact dates and the publisher. You may include these details in your bibliography, but the bibliography will appear inconsistent if you do not provide the same details of all your sources. References to theses, reports and datasheets *[6–8]* are formatted in the same way as other types of sources. You may also include the identifiers of datasheets in your bibliography.

[1]	M.J. Weber, Handbook of Lasers, CRC Press, Boca Raton Florida, USA, 2001, 300 p.	*book*
[2]	S. Cattaneo, E. Vuorimaa, H. Lemmetyinen, M. Kauranen, Advantages of Polarized Two-beam Second-harmonic Generation in Precise Characterization of Thin Films, Journal of Chemical Physics, Vol. 120, Iss. 19, 2004, pp. 9245–9252.	*journal*
[3]	T. Kaunisto, Talousvesijärjestelmien turvallisuus paranee, Vesitalous, No. 6, 2003, pp. 7–9.	*journal*
[4]	W. Li, M. Pessa, T. Jouhti, C.S. Peng, E.-M. Pavelescu, GaInNAs Quantum Well Lasers, in: Nalwa, H.S. (ed.), Encyclopedia of Nanoscience and Nanotechnology, Vol. 3, American Scientific Publishers, 2004, California, USA, pp. 719–730.	*conference proceedings*
[5]	F. Wai-ling Ho-Ching, J.Mankoff, J.A. Landay, Can you see what I hear?: The Design and Evaluation of a Peripheral Sound Display for the Deaf, Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, Ft. Lauderdale, Florida, USA, April 5–10, 2003. New York, NY, ACM Press, pp. 161–168.	*conference proceedings*
[6]	A. Puhakka, Weakest Congruences, Fairness, and Compositional Process-algebraic Verification, dissertation, Tampere University of Technology, Publication 468, 2004, 176 p. Available: http://dspace.cc.tut.fi/dpub/bitstream/handle/123456789/87/puhakka.pdf?sequence=1	*dissertation*
[7]	M. Ohlström, E. Tsupari, A. Lehtilä, T. Raunemaa, Pienhiukkaspäästöt ja niiden vähentämismahdollisuudet Suomessa - Kasvihuonekaasupäästöjen rajoittamisen vaikutukset, VTT Tiedotteita 2300, Espoo 2005, 91 p. Available: www.vtt.fi/inf/pdf/tiedotteet/2005/T2300.pdf	*report*
[8]	OMAP4430 Multimedia Device Data Manual, Texas instruments, Literature Number: SWPS041D, Dec 2012, 443 p. Available: http://www.ti.com/lit/gpn/omap4430	*datasheet*

Your bibliography may also include other types of sources. Thirteen examples of citing different types of sources are listed below: journal article with unknown author *[9]*, book with unknown author *[10]*, website *[11,12]*, standard *[13]*, patent *[14]*, regulation *[15]*, unpublished source *[16,17]*, list and table *[18, 19]*, instructions *[19],* and interview *[20]*.

If the author is unknown, the reference starts with the publication title, as in *[9,10]*. It is important to include as full details as possible on websites, such as *[11,12]*. You can test whether search engines, such as Google, can find your source based on the details that you have provided. The format is largely the same regardless of the type of electronic publication (website, electronic journal, blog, and so on). The date when you accessed electronic sources should also be mentioned. As electronic sources may be questionable sources of information, you should primarily use official and peer-reviewed publications,

if possible. Long URLs should not be randomly shortened.[2] Please consult a dictionary, if you have to syllabify long words that do not include an obvious prefix and are not compound words. Standards *[13]*, patents *[14]* and regulations *[15]* have earlier been referred to in quite unusual ways, but in this guide the formatting requirements are consistent.

Occasionally articles become available before they have been published, such as Yan et al. *[16]*, and therefore the number of the issue and page numbers remain unknown. In the example provided below, the journal has officially announced that the article will be published ("*accepted for publication"*). The example *[17]* is somewhat questionable, but it is better to include a source than claim something without a reference. Lists, tables and instructions *[18–20]* are included in the bibliography as any other sources. A personal interview *[21]* is a special type of reference that is occasionally needed.

[9]	Injection Molding, Plastics Technology, Vol. 51, Iss. 9, 2005, pp. 13–16.	*journal, unknown author*
[10]	Raaka-ainekäsikirja 5 - Alumiinit, Metalliteollisuuden keskusliitto MET, Helsinki, 2002, 250 p.	*book, unknown author*
[11]	Intel Timeline: A History of Innovation, Intel Corporation, website. Available (accessed on 24.6.2013): http://www.intel.com/content/www/us/en/history/historic-timeline.html	*electronic material*
[12]	J. Davies, A. Duke, Y. Sure, OntoShare - an Ontology-based Knowledge Sharing System for Virtual Communities of Practice, Journal of Universal Computer Science (JUCS), Vol. 10, Iss 3, 2004, pp. 262–283. Available (accessed on 23.8.2005): http://www.jucs.org.	*electronic material*
[13]	SI units and recommendations for the use of their multiples and of certain other units, Finnish Standards Association, SFS–ISO 1000+A1, Helsinki, 1999, 43 p.	*standard*
[14]	J. Keskinen, M. Moisio, M. Marjamäki, A. Virtanen, J. Ristimäki, Menetelmä hiukkasjakauman ominaisuuksien mittaamiseksi, Pat. FI 115074, Hak.nro FI 20011668, 20.8.2001 (28.2.2005), 19 p.	*patent*
[15]	Sähköturvallisuuslaki, L 14.6.1996/410, 1996. Available: http://www.finlex.fi/fi/laki/ajantasa/1996/19960410.	*regulation*
[16]	Y. Pan, G. Dong, T. Zhang, Error Rate-Based Wear-Leveling for NAND Flash Memory at Highly Scaled Technology Nodes, IEEE Tran. Very Large Scale Integration (VLSI) Systems, accepted for publication, 2013.	*accepted for publication*
[17]	Tampereen teknillisen yliopiston diplomitöissä käytetyt viittausjärjestelmät, Tampere University of Technology Library, Tampere, 2005, unpublished report, 5 p.	*unpublished*
[18]	Physical Constants of Inorganic Compounds, in: Lide, D.R. (ed.), CRC Handbook of Chemistry and Physics, 85th ed., Boca Raton 2005, CRC Press, 96 p.	*list*
[19]	Tärkeimpiä luonnon radionuklideja ja niiden ominaisuuksia - Appendix 1, in: Pöllänen, R. (ed.), Säteily ympäristössä, Säteilyturvakeskus, Säteily- ja ydinturvallisuus 2, Helsinki, 2003, pp. 374–376.	*table*
[20]	Kalkkihiekkatiilet - Muuraustarvikkeet, Building Information Group, RT–10834, 2004, 4 p.	*instructions*
[21]	V. Miettinen, MSc (Tech), CEO, Company Ltd, Ypäjä. Interview on 25.5.2005.	*interview*

The large number of examples provided above does not indicate that the entries should be differently formatted in your bibliogrpahy. On the contrary, it is possible and important

[2] In MS Word use the symbol no-width optional break, or in LaTeX the command \discretionary{}{}{}.

to refer to completely different sources in a consistent way in order to ensure that your thesis is neat and presentable. Official and extremely detailed instructions for referencing are included in the SFS Standard [14].

5.5 Common mistakes

Referencing is an integral part of all scientific writing. Some common mistakes in citing references are listed below. You can easily avoid these mistakes by carefully reviewing your written works.

1. Do not assume that something is generally known. Whenever you state that something is better, faster or cheaper than something else, you need to add a reference to verify your claim. You also need to specify the magnitude (for example, does cheap mean 1 cent, EUR 1 or EUR 100?).
2. Use multiple sources. Refer to articles by different authors and explain the differences and similarities between their theories and results. Terms may also be used and understood differently in your sources. If you state that something occurs “commonly”, you need to provide multiple references to back up your claim.
3. Clearly describe how your research builds on the existing body of research. Your thesis is not written in a vacuum. You need to specify the differences and similarities between your research and the work of others and demonstrate the novelty and originality of your research.
4. Focus on the factual content of your sources. When you are reporting background information and the results of previous research, try to find the same information in multiple sources. Write down all bibliographical information whenever you take a note; it will make your job a lot easier later on.
5. Keep your bibliographic references and citations consistent throughout your thesis. A neatly and consistently formatted thesis will help you get your message across and portray a professional image. The most important thing is to be consistent and, for example, list the details in the same order (name, title… Available) and format (*J. Davies* vs. *Davies, J*. vs. *John Davies*, or *Dec.* vs. *December*). Use only one style to write the names of conferences. Examples are (in order of preference): *in the proceedings of the IEEE International Symposium on Circuits and Systems (ISCAS)* vs. *In Proceedings of ISCAS* vs. *In ISCAS* vs. *Proc. ISCAS* vs. *ISCAS*.
6. Make sure that your bibliography does not include sources that are not referred to in the main body of your thesis. When you edit your thesis, it is possible that you delete an in-text citation but forget to delete the bibliographic entry.
7. Do not repeat mistakes found in your sources. Some of your sources may be unclear or lack essential information. Make sure that you do not make similar mistakes in your thesis.
8. Take careful notes when citing numerical data. Your source may include a great deal of numerical data, but you may only have to cite one number. You need to keep track of all the numbers have your have retrieved from specific sources.
9. Make sure that others can easily cite your written works later on. All the documents you write should include the basic information listed in Subchapter 5.4. This especially applies to reports, PowerPoint presentations and memos.

5.6 Copyright

You need to observe possible restrictions imposed by copyright laws when you incorporate other people’s work, which is subject to copyright laws, in your thesis. In principle,

you do not have to seek permission to cite works that are protected under the Finnish Copyright Act (such as materials authored by people permanently residing in Finland), but you must always give credit to the original source [17].

It is acceptable to quote the works of others, as long as you comply with the following requirements [8][9]:

1. You must always credit the original author and source.
2. Quotations must be offset from the rest of the text.
3. Quotations may not be too long or too short or mislead the reader. You must always retain the meaning of the original text.
4. The source must be quoted verbatim, word for word (you may not, for example, correct misspellings in a direct quotation).
5. Quotations must have a relevant connection to your own work. The cited text, picture or graph must serve to provide, for example, further information or substantiate your line of reasoning. They may not drown out your own voice.

Copyright protection is automatically granted to the creator of an original work of authorship. The types of works that fall into this category are listed in the Finnish Copyright Act, but the list is not exhaustive.

If a work is not considered an original work of authorship, it is not covered by copyright. Ordinary graphs (bar graphs and line graphs) and block diagrams, for example, in a datasheet, rarely qualify as original works of authorship. They would be easy to reproduce, if the source data were available. However, good scientific practice dictates that they, too, must be appropriately cited. Photographs are often protected by copyright.

Original works of authorship are protected under the copyright laws of the countries where they originated. Foreign copyright laws may be more stringent than the laws of Finland, and you may need to secure permission to cite materials, which can be quite difficult. For example, the IEEE database displays a link next to each publication, so you can request permission to reproduce content in your coursework or article [7]. In most countries copyright legislation complies with international standards and is therefore largely similar. However, the USA follows the doctrine of *fair use*, which permits limited use of copyrighted material for the purposes of criticism, comment, news reporting, teaching, scholarship and research.

Please be aware that authors may impose additional restrictions on the reuse of their works. Works that are available under a CC license (Creative Commons) can usually be reproduced for research purposes without obtaining permission from the author. The scope of CC licenses may vary, so you need to familiarize yourself with the specific terms and conditions before applying the licenses.

6. THESIS LAYOUT

The thesis template helps you automatically format your dissertation to meet the University's requirements. During the Spring 2019 the thesis templates are available in the POP portal after which they will be made availbale in the Tampere University student portal.

This chapter includes some additional instructions. Your choice of word processor also determines how quickly and easily you can edit your text.

Bachelor's theses and master's theses are submitted for review in electronically in PDF A-format. Theses are also stored in PDF format in the University's institutional repository and published on-line with the student's permission.

If you would like to have a bound copy of your master's thesis contact the bindery early on, because binding your thesis will take at least a couple of working days. The University does not require a printed or binded copy of the thesis in any case.

6.1 Page layout and font

A thesis is written with a single-column layout. In case you want to bind your thesis, it can be printed on one- or two-sided A4 sheets (210 mm x 297 mm). If the total number of pages is less than 80, the thesis must be printed on one-sided sheets. The width of the binding margin is 4.0 cm, the outer margin is 2.0 cm, and the top and bottom margins are 2.5 cm (see Figure 6). Page numbers start from the Introduction. The pages preceding the Introduction, apart from the title page, are numbered with Roman numerals (i, ii,...), the page number of the Abstract is i.

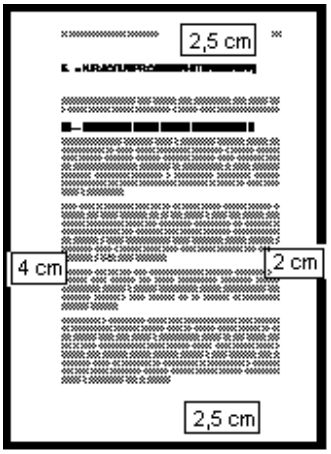

Figure 6. *Margins.*

Page numbers are placed on the outer corner of the top margin. You can place the heading of each chapter into the inner corner of the top margin, but not on the first page of

the chapter. The text in the top margin may be separated from the body text with a thin horizontal line.

The abstract font type is Arial and the size is 10 points. In the abstract, the line spacing is 1. and the text is fully justified and hyphenated. Paragraphs are indented. In the actual body text the font type is Arial and the size is 12 points and the line spacing is 1,5 points. After each paragraph there is a space of 6 points..

You can find mathematical symbols and Greek letters in the LaTeX macros and modes, such as $\Theta(n^2)$ or *\begin{equation} \sin(\frac{\pi}{2}) = 1 \end{equation}*. If you use MS Word, you can find them in the menu Insert > Symbol (or Equation).

6.2 Chapters and headings

The minimum length of chapters and subchapters is two paragraphs, and you need to consider the balance of chapters. Each paragraph discusses a specific theme or the relationship between two themes. It is easiest to separate paragraphs by leaving a blank line between them. Paragraphs must always consist of more than one sentence. If you use subchapters, there must be at least two of them (e.g. 6.1 and 6.2). Do not use more than three levels of headings, such as 4.4.2.

A good heading catches the reader's interest and organizes the text into a logical outline. The heading summarizes the topic of the chapter. Headings should not contain more than 5–6 words, and major headings always start a new page. Do not allow a subheading to stand as a widow line at the bottom of the page: there must be at least two lines of text following the subheading. When you refer to a particular chapter, mention only the number ("in Chapter 2", "in Subchapter 3.1"), except when you write "in this chapter" or "in the following chapter".

Headings are in a larger font size than the body text, and they are preceded and followed by vertical space. For example, Arial 18 pt is the font/size of headings in this guide, and there is a 42 pt space above and below. The font size of subheadings is 14. There is an 18 pt space above subheadings and 12 pt space below them.

Typefaces can be classified as being serif (such as Times New Roman) or sans-serif ("without serifs", such as Arial) based on the small lines called serifs tailing from the edges of letters. Serifs are popular in lengthy printed texts, since the serifs are thought to help to distinguish each letter and make it easier to read strings of characters. Sans-serifs are considered to be more legible on computer screens.

7. CONCLUSION

This guide provides an introduction to the structure and layout of theses, referencing styles and scientific writing. Students prepare a thesis to demonstrate their competence in their field of study. The working group that prepared this guide has made every effort to ensure that the instructions provided herein are as clear and understandable as possible.

The structure of a thesis is very similar to that of other scientific papers. You need to demonstrate how your research builds on previous research, specify the research problem that you set out to address, discuss the novelty of your research, and describe your results. The theoretical framework and background information is presented in as much detail as is necessary for your readers to form an overall picture of your research. The results and their importance are described clearly and thoroughly. The format of your thesis must consistently follow one style.

Table 4 sums up the key stages of the process of updating this guide. You can include a similar table in your thesis. Depending on the content, you can place the table, for example, in the chapter titled Results or Analysis.

Table 4. *Brief summary of the process of updating this guide.*

Objective	Revise thesis writing guide for technical fields in Tampere University
Time frame	September -November 2018, working hours > 50 h
Results	Revised guide, 65 pages incl. appendices, updated document templates.
Main changes	Updated thesis process and terms to correspond to the new Tampere University regulations.
Main problems	Schedule, different conventions of academic disciplines, word processing software.

You must follow the principles of academic integrity and good scientific practice and include a large number of references and citations in your thesis, so that readers can locate the original sources and verify your claims. You can use one of the two common referencing styles: the numeric system or the name-year system. Most of the formatting requirements are the same regardless of the referencing style, but you need to pick one and use it consistently throughout your thesis. Cite multiple authors and analyse the

similarities and differences between your sources. It is important that you describe how your research builds on the existing body of research in your field.

Make sure that your references and text are neatly formatted in accordance with the provided instructions. You should always keep your readers in mind as you write. Nevertheless, effective communication and the reproducibility of your results are more important than strict observance of formatting requirements. Tables, figures and mathematical notations allow you to display a great deal of information in an accessible and concise format. Every figure and table requires comment in the main body of your thesis. All figures and tables must be numbered consecutively throughout the text.

Students write a thesis to demonstrate their ability to work independently and solve problems and to develop their scientific writing skills. You continue to revise and polish your objectives, results and text throughout the writing process. Set yourself ambitious but realistic goals and try to ensure that you make steady progress towards the completion of your thesis. Hard work and a positive attitude are the keys to overcoming any obstacles that may come your way. Remember that reading makes you a better writer.

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APPENDIX 1: TITLE PAGE

Tampereen yliopisto

Tomi Teekkari

EVALUATION OF THE USER-CENTEREDNESS IN IMPLEMENTATION OF THE ENTERPRISE RESOURCE PLANNING SYSTEMS

Sub-heading

Faculty of Business and Management
Master's Thesis
March 2019

ABSTRACT

Faculty of Management and Business
Tomi Teekkari: Evaluation of the User-centeredness in Implementation of the Enterprise Resource Planning systems
Master's Theses
Knowledge Management
March 2019

The implementation of an Enterprise Resource Planning (ERP) system is one the most important stages in a company's ERP project since failure at this stage might have seri-ous consequences, such as bankruptcy. This thesis examines the implementation models of ERP systems and the basis on which implementations are carried out in the customer company by the ERP system contractor. The main goal is to clarify how user-centred implementation is performed and find ways to make the implementation process more effective and successful.

The thesis is divided into two parts. In the literature review, issues related to ERP im-plementations are explored. Usability, user-centeredness and change management are all considered. It was found that measurement results are practically non-existent in previ-ous literature. In the interview research part, four ERP system implementation models are investigated and compared with ISO 13407 standard of Human-centred design pro-cesses for interactive systems. Each ERP system implementation model studied here has been examined using an actual customer case with its supplier to provide a practical di-mension to the theoretical approach. A total of 28 persons were interviewed in various organizations.

The study indicates that ERP implementation models and the user-centred design pro-cess are closely related. End users get involved already at the specification stage, whereby the business processes of the company and the requirements for the system from the perspective of users and the organization are defined. Multidisciplinary design teams redesign the business processes of the company to seamlessly combine them with the implemented ERP system. The main obstacles are frequent organizational reforms, unclear company strategy, excess bureaucracy, and poor interoperability of information systems. This thesis presents 8 guidelines to improve such projects.

The results of this study suggest that, by considering user-centeredness at the implementation stage, the process is accelerated and acceptance of the system is enhanced. At the same time, the system becomes more effective to use and it becomes more likely that the business goals and expected benefits are achieved. Although the exact speedup is not yet known, it is expected to lie in the range of 5–15 %, which means an average of 1–3 calendar months

Key words: Enterprise Resource Planning, implementation model, implementation, usability, user-centred design process, change management

TIIVISTELMÄ

Tomi Teekkari: Toiminnanohjausjärjestelmien käyttöönoton käyttäjäkeskeisyyden arviointi
Tampereen yliopisto
Tietojohtamisen tutkinto-ohjelma
Diplomityö
Maaliskuu 2019

Toiminnanohjausjärjestelmän (engl. Enterprise Resource Planning systems, ERP) käyttöönottoprojekti on yksi yrityksen ERP-hankkeen tärkeimmistä vaiheista, koska se epäonnistuessaan saattaa kaataa koko yrityksen. Tässä työssä tutkitaan ERP-järjestelmien käyttöönottomalleja, joiden pohjalta asiakkaan käyttöönottoprojektit järjestelmän toimittajan kanssa toteutetaan. Työn tavoite on selvittää, kuinka käyttäjäkeskeisesti käyttöönottoprojektit toteutetaan, ja etsiä käytettävyydestä keinoja käyttöönottoprojektin tehostamiseen ja onnistuneeseen läpivientiin.

Työ jakaantuu kahteen osaan. Kirjallisuustutkimusosa esittelee ERP-järjestelmien käyttöönottoon liittyviä tekijöitä ottaen huomioon käytettävyyden, käyttäjäkeskeisyyden ja muutosjohtamisen näkökulmat. Työssä havaittiin, että aiempia mittaustuloksia on niukalti tai ei lainkaan. Haastattelututkimusosassa tutkitaan neljän ERP-järjestelmän käyttöönottomalleja ja verrataan niitä ISO 13407 -standardiin Vuorovaikutteisten järjestelmien käyttäjäkeskeisestä suunnitteluprosessista. Lisäksi jokaisen tutkitun ERP-järjestelmän käyttöönottomalli käydään läpi kunkin toimittajan esittelemän todellisen asiakastapauksen avulla konkretisoimaan teoreettista toimintatapaa. Yhteensä haastateltiin 28:aa ihmistä eri organisaatioista. Tutkittujen järjestelmien käyttöönotto vei 4 11 kuukautta.

Tutkimus osoittaa, että tutkituilla ERP-järjestelmien käyttöönottomalleilla on yhteys käyttäjäkeskeiseen suunnitteluprosessiin. Käyttäjät otetaan mukaan jo määrittelyvaiheessa, jolloin määritellään yrityksen liiketoimintaprosessit sekä käyttäjien ja organisaation vaatimukset käyttöönotettavalle järjestelmälle. Määrittelyjä tekevät monialaiset suunnittelutiimit, ja niillä pyritään saamaan liiketoimintaprosessit ja käyttöönotettava ERP-järjestelmä saumattomasti toimivaksi kokonaisuudeksi. Suurimmiksi ongelmiksi osoittautuivat jatkuvat organisaatiouudistukset, yrityksen sekava strategia, liiallinen byrokratia sekä tietojärjestelmien huono yhteensopivuus. Tässä työssä annetaan 8 suositusta tällaisia projekteja varten. Tutkimuksen perusteella voidaan olettaa, että käyttäjäkeskeisyyden huomioon ottaminen käyttöönottoprojektissa nopeuttaa sitä ja vaikuttaa järjestelmän hyväksymiseen. Samalla ERP-järjestelmän käyttö tehostuu ja tavoitellut liiketoiminnalliset hyödyt saavutetaan paremmin. Tarkka nopeutus ei ole tiedossa, mutta sen arvioidaan olevan parhaimmillaan 5–15 %, joka vastaa keskimäärin noin 1–3:a kalenterikuukautta.

Avainsanat: Toiminnanohjausjärjestelmä, ERP, käyttöönottomalli, käyttöönottoprojekti, käytettävyys, käyttäjäkeskeinen suunnitteluprosessi, muutosjohtaminen

APPENDIX 4: WRITING INSTRUCTIONS

Electronic resources
Google Scholar (http://scholar.google.fi/) provides a simple way to broadly search for scholarly literature.

Please visit the Library's website for more information. You can access the electronic resources on campus or by setting up a remote connection to the campus network.

Reference management software, such as RefWorks and Mendeley.

Instructions for depositing your thesis in DPub are available in the POP portal: POP> Study info > Master's thesis > Online publication.

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