

Academic Writing

Seminar Notes (1.0)

AS 2024

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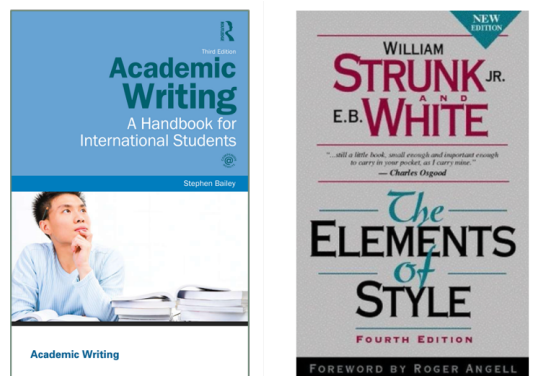
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Disclaimer

- The author of these notes is not a native English speaker.
- This document contains information and recommendations exclusively for students writing their BSc or MSc thesis in the Pattern Recognition Group. That is, this document does not necessarily apply for students of other research groups.
- These notes do not correspond to an English course in the strict sense – it is merely a compilation of best practices in writing based on my experience as a scientific writer.

References The content of these notes is largely based, or copied from, two books.

- Bailey, Stephen. Academic writing: A handbook for international students. Routledge, 2014.
- Strunk, William, E. B. White,. The Elements of Style. SWB Books, 1918.



We recommend that you buy them both in order to obtain a broader and deeper basis on the subject of academic writing (including further topics, exercises, examples, etc.).

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Chapter 0

Formal Requirements

Once you have agreed with your supervisor on a topic, get the confirmation from the director of studies that you are allowed to start the BSc thesis (to do this, you need to send a request to the office manager of the director of studies). For a MSc thesis, follow the *JMCS process*.

The standard duration to complete a bachelor thesis is five months (extensions are allowed after consultation with the supervisor).

A thesis has to be written with the aid of L^AT_EX not with Microsoft Word (or similar word processing software). For BSc theses a template is available on the PRG website. For MSc theses, a template is available on the JMCS website. Additionally, we recommend to use the following tools:

- Overleaf, TexMaker, or similar for L^AT_EX editing
- BibDesk, Zotero, or similar for managing the bibliography
- GraphViz for drawing graphs, trees, flowcharts, etc. Alternatively use draw.io, OmniGraffle, LucidChart (partly fee-based software and partly not available for all platforms)

- GnuPlot, Matplotlib, Seaborn, or similar for plotting data and results.

We also recommend using language tools such as DeepL or chatGPT to iteratively improve your own text fragments. What we do not recommend *under any circumstances* is to create entire paragraphs using these tools – we expect you to have a certain seniority in evaluating the results you get from these tools¹.

For BSc theses we expect a length of about 30 pages, for MSc theses about 50 pages are appropriate. These are – of course – rough rules of thumb. The actual number of pages of the thesis depends on the type and content of the scientific work.

BSc theses can be written in German or English (English is highly preferred). MSc theses must be written in English.

The final version of a thesis consists of a single PDF file. Printed copies are not needed.

The assessment of a BSc thesis consists of three grades:

- *Bachelorarbeit*: Assessment of the final version of the thesis
- *Seminar*: Assessment of the presentation given in the seminar (for details of the grading scheme we refer to the document *Information for the Pattern Recognition Seminar*)
- *Anleitung zu wissenschaftlichen Arbeiten*: Assessment of the scientific approach and procedure. In the vast majority of cases,

¹Misuse of chatGPT, or similar, can lead to an accusation of plagiarism.

this grade corresponds to the same grade as the grade for the thesis. In exceptional cases, however, the grade may differ – for example, to recognize a high level of commitment, a special innovation that goes beyond the initially defined objectives, or a particularly extensive and well-defined experimental evaluation.

The assessment of a MSc thesis consists of one grade and written statements on the following items:

- Has the candidate reviewed, integrated and cited relevant scientific literatures sufficiently?
- Qualification of the scientific research work of the candidate in terms of work organisation, personal effort, aptitude, creativity.
- Relevance of addressed questions and quality of obtained results. Have the aims of the study been met?
- Analytical abilities and interpretation of the results.
- Editorial formulation and layout of the thesis including figures and tables.
- Independent workability of the candidate.

Normally, we grade a submitted thesis within two to three weeks and offer – if desired – a discussion of the evaluation.

If a thesis has serious deficiencies, the thesis will be graded with a grade smaller than 4.0 (insufficient). Yet, if a thesis has deficiencies that can be corrected within a reasonable period of time, we might reject the initial submission. If the student decides to correct these deficiencies within a defined period of time, a passing grade is still possible (typically a grade of 4.0).

Chapter 1

Purpose and Elements of Academic Writing

1.1 Purpose of Academic Writing

Writers of academic texts should be clear about *why* they are writing. Among the most common reasons for writing in the area of academics are the following.

- to report on a piece of research that the writer has conducted (e.g., to report on your BSc or MSc project)
- to answer a question that the writer has been asked or has chosen to answer
- to discuss a topic of general interest and to present the writer's opinion
- to summarize the research conducted by others on a topic

In all cases it is useful to bear in mind the readers of your work. In our specific case – i.e., when writing a thesis in the field of computer science – we generally assume an interested computer science student

at the master's level. You should always have this student in mind as you write.

- How can you effectively explain your ideas to him/her?
- What level of knowledge can I expect from this student?
- What procedures/ways of thinking is he/she certainly with?
- Where might he/she need a reminder?
- Where could an example or illustration be helpful?
- etc.

Although there is no fixed standard of academic writing, it is clearly different from the written style of newspapers or novels. It is generally agreed that academic writing lays claim to the following characteristics.

Academic writing ...

- ... is accurate and objective
- ... uses formal vocabulary
- ... lacks idioms
- ... uses impersonal style
- ... includes equations, definitions, proofs, algorithms, etc.
- ... uses citation and includes references
- ... uses both passive and active voice (in other areas active voice is often preferred)

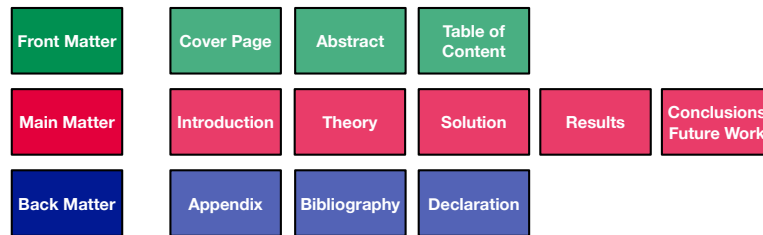


Figure 1.1: The key elements of a thesis grouped into front, main, and back matter.

1.2 Elements of Academic Writing

Most of the BSc or MSc theses consist of the following key elements (see also Fig. 1.1):

- Front Matter
 - Cover Page (with Title)
 - Abstract
 - Table of Contents
- Main Matter (five chapters of the thesis¹)
 - Introduction
 - Theory
 - Solution
 - Results
 - Conclusion
- Back Matter
 - Appendix
 - Bibliography
 - Declaration of Authorship

¹Note that these are just generic chapter titles – please use more descriptive titles in your work.

1.2.1 Front Matter

Cover Page The cover page contains the most important data about the institution, the author and the written work, so that all necessary information can be grasped briefly (→ use the templates).

Probably the most important (or only) decision of the cover page is the title of your thesis. Sometimes this is already given by the project proposal – however, these are usually only working titles and you are free to choose a more appropriate title for your actual thesis.

- The title should inform what the thesis contains.
- The title (in normal font) should not be longer than one line.
- The title can also be provided with a subtitle.
 - Here, the title consists of only a few words and should arouse the reader's interest.
 - The subtitle gives more information about the analysis or topic direction.
 - It should never repeat the information of the title.

Abstract An abstract is intended to give the reader a summary and thus provide an overview of the main points of the thesis. An abstract should be precisely worded and self-contained. Avoid citing sources in your abstract. The abstract must be understood by someone without prior knowledge of the topic. It is limited to approximately 150-300 words and should not be longer than one page. Write the abstract at the very end of the thesis production process.

Sometimes students have difficulty distinguishing the abstract from the introduction. The *purpose* of the two elements is the main differentiator.

- Purpose of an introduction: Broadly introduce your topic and your goals as well as outline the content of your thesis
- Purpose of an abstract: Give an overview of your entire project, in particular its findings and contribution to the field

Usually an abstract includes the following six items (and answers the shown questions):

1. The context and background for your research (i.e., the general as well as the specific topic of your project)
 - What is already known? What is your thesis about?
2. Brief explanation of the topic's relevance
 - Why is it important? Are you researching a new topic? Bridging a gap in previous research? Applying new methods to existing data? Resolving a dispute in the field? etc.
3. The central research question(s) and major goal(s) of your project
 - What is the goal? What do you want to achieve?
4. An indication of your research methods and approach
 - How did you do it?
5. A summary of your key findings and most important results
 - What did you find?

6. The significance and main conclusions of your findings

- What are the conclusions of your project? Why are your findings important?

Table of Contents The table of contents reflects the structure of the thesis and gives a first impression of the content, and thus also of the quality of the work. The table of contents makes it easy to check if topics are balanced across the thesis and if the titles of sections are consistent. Moreover, you can readily check if every outline section includes at least two separate sections, i.e., Section 2.1, for instance, has to be followed by at least Section 2.2 (details about structuring a thesis follow in the next chapter).

The hierarchy of sections should be limited to a maximum of three levels. Thus, Chapter 2 could be divided, for instance, into Sections 2.1, 2.2, 2.3, ... and Section 2.x into Subsections 2.x.1, and 2.x.2. The final division into *subsubsections* is then on level 2.x.x. Note, however, that the provided templates do not show the numbering on this level anymore and subsubsections are not listed in the table of contents either.

The bibliography and appendix are also indicated in the table of contents with page numbers (→ use the templates).

1.2.2 Main Matter

Introduction The final version of the introduction is written *after* one has finished the other chapters of the thesis. However, *before* one starts writing the other chapters, it is helpful to write down in bullet

points what will be in the introduction to have clarity about what you are getting at. If you know whether something is covered in the introduction or not, you will also know whether a certain concept needs to be introduced or explained in one of the next chapters (and if so, to what level of detail – because it is perfectly fine to introduce something informally in the introduction and then formalize and elaborate on it in greater detail in one of the later chapters).

Guideline for the length of the introduction: It should be about 10% of the total thesis length, i.e., for a 30-page thesis, the introduction should be about 3 to 4 pages.

In contrast to the abstract, the introduction is *not* a summary in which the results are anticipated, but a content-related introduction that should invite the reader to read on. Three Questions should be answered in the introduction:

- What is the *topic* and *context*, what are the *goals*, and how is the thesis *organized*?

Thus, a typical introduction covers three parts:

- *Topic and Context*: In the very first part of the introduction the topic should be placed in larger context by embedding the project in a top-down manner.

For example, if your topic is in the field of, say, *Iris Recognition* (see Fig. 1.2), then one can start the introduction by describing that the present thesis is in the field of Artificial Intelligence (AI).

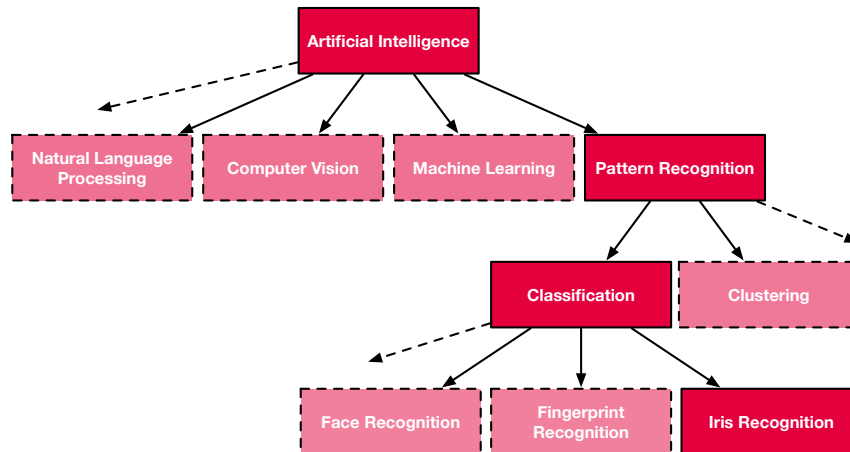


Figure 1.2: The topic *Iris Recognition* is placed in larger context in a top-down manner.

Eventually, one describes in a few paragraphs what AI encompasses – here one mentions, among others, that Pattern Recognition (PR) is also one of the sub-branches of AI. Then one goes down a level and describes PR in a few paragraphs as one of the many sub-branches of AI. Next, one goes down a further level and explains that PR can be subdivided into, for example, Classification or Clustering. Finally, as Iris Recognition falls into the field of classification, one describes in a few paragraphs some typical classification tasks (one could pick tasks which are somehow related to iris recognition), and finally one arrives at the actual topic of the thesis.

- *Goal(s)*: Next, the introduction should contain a clear statement of the research question. That is, one has to introduce the major goal (and possible subgoals) of the project and ultimately answer the question what one wants to achieve with the thesis. This also includes a clear motivation and description of the scientific relevance of the research question.

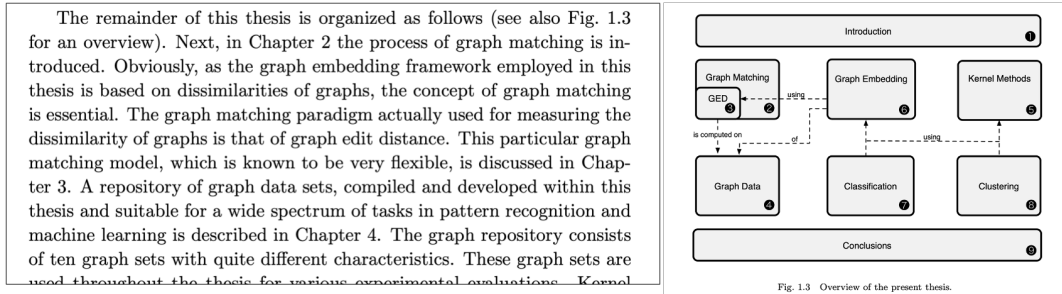


Figure 1.3: An outline of a thesis (in text form and graphically).

Note: Sometimes optional goals are defined for a research project (typically when discussing the project with your supervisor during a kick-off meeting). However, these optional goals are only mentioned in the final thesis if they have been actually achieved (and then they are *not* named as optional).

- *Outline*: Finally, at the end of the Introduction one should briefly show how the further structure of the thesis is organized. This includes the flow, what will be dealt with in which chapter (see Fig. 1.3).

Theory, Solution, Results After the introduction, the centerpiece of your work follows (which makes up about 80% of the total work – so with 30 pages, about 24 pages). The structure of this part depends on the research question, the method and the topic.

In our research group, many theses are organized as empirical theses that focus on the development and research of a novel method or algorithm applied to some data sources to solve a specific problem. The main part of the thesis can thus be divided into three chapters²:

²Note that *Theory*, *Solution*, and *Results* are generic chapter titles – please use more descriptive titles.

- *Theory*: In this chapter, the research question is embedded in a theoretical context and the current state of research in the literature is thoroughly presented in its main points. We suggest to use the same embedding and structure as in the introduction — make sure you go into much more detail here than in the introduction (also, rephrase your own sentences and do not merely copy the text from the introduction).

The central research question(s) and major goal(s) are formally specified and it is shown what science has found out about the topic so far. The theoretical discussion also serves to develop the hypothesis.

- Which relevant theories and explanations are used to answer the research question?
- Which hypotheses can be derived from this for the research work?

A common question is the level of detail this chapter should achieve. The rule of thumb is that the more important a theory is to your work, the more detailed you should actually describe it. For example, if *graphs* are very important and build the basis to your work, you should formally introduce and thoroughly explain the concept of a graph. On the other hand, if you only *use* a certain concept (and this component is virtually interchangeable and not a central part of your own work), you can explain this concept in a few sentences – this is often true for certain algorithms used in the evaluation (e.g., an SVM classifier). But be careful. For example, if you see that certain parameters/details

of the concepts used cause large differences in the empirical evaluations, you may need to explain and define these parameters in more detail, even though you are only "using" the concept.

- *Solution*: This chapter describes in detail the developed solution and the researched method. Typically, this chapter presents and discusses developed algorithms, the implemented framework (including code fragments), as well as data sources and data structures.

Display algorithms and procedures by means of the L^AT_EX packages `algorithm` and `algorithmic` (→ use the templates). The displayed algorithms must be described in the body text of the work. That is, thoroughly describe what happens on which line of the algorithm and for what purpose.

Display code (e.g., Python or Java code) by means of the L^AT_EX package `minted` (→ use the templates). Do *not* screenshot your code fragments. Here, too, you must describe the key components and features of your source code in detail and precisely – only show your code if there is something to say about it.

A common question is how much of one's code should be shown in the thesis. As a rule of thumb: As little as possible but as much as necessary to estimate the programming effort. We recommend showing and commenting on key passages or particularly exciting parts of the code only. More complete excerpts from the implemented code can be shown in the appendix (if necessary).

- *Results*: In this chapter, the empirical results are clearly presented and critically discussed. In addition, an attempt can be made to place them in a broader (theoretical) context.
 - What are the results of the empirical investigation?
 - Could the initial hypotheses be confirmed or do they need to be modified?
 - How can they be assessed against the background of existing research findings?
 - What are the strengths or weaknesses of the chosen empirical approach?
 - Which quality criteria are fulfilled by the obtained results?
 - etc.

Conclusion and Future Work The conclusion rounds off what has been written and, together with the introduction, forms the framework of the entire thesis. The conclusions should be different in content from the abstract, and be rather longer too. Approximately 10% of the total length of the thesis is devoted to the conclusion

- The central questions should be revisited and discussed (and contextualized).
- The developed method is summarized.
- The main results and other important content should be presented again, and one should comment critically on them.
- Here one shows what answers one has found to the questions and reviews the significance of the project.

Open questions and an outlook to future research should also be formulated. The future work might address the following questions:

- Is the main question posed in the introduction completely answered in the present thesis?
- Is the developed solution convincing?
- Are there shortcomings and problems in the present work?
- Are there any ambiguities?
- What could be investigated or improved following this or what investigations would have to follow?
- Where are further findings missing?

1.2.3 Back Matter

Appendix Extra material may be placed in an appendix that appears after the conclusion. Typical content of an appendix is, for instance,

- code of the developed solution
- complete sets of figures
- proofs that are mentioned in the thesis
- etc.

That is, in the main part of the thesis one shows only the highlights of the code or exemplarily a few figures which support the main findings and then one refers to the corresponding sections in the appendix for the sake of completeness.

Erklärung

gemäss Art. 30 RSL Phil.-nat.18

Name/Vorname:

Matrikelnummer:

Studiengang:

Bachelor ☒ Master ☐ Dissertation ☐

Titel der Arbeit:

LeiterIn der Arbeit:

Ich erkläre hiermit, dass ich diese Arbeit selbständig verfasst und keine anderen als die angegebenen Quellen benutzt habe. Alle Stellen, die wörtlich oder sinngemäss aus Quellen entnommen wurden, habe ich als solche gekennzeichnet. Mir ist bekannt, dass andernfalls der Senat gemäss Artikel 36 Absatz 1 Buchstabe r des Gesetzes vom 5. September 1996 über die Universität zum Entzug des auf Grund dieser Arbeit verliehenen Titels berechtigt ist. Für die Zwecke der Begutachtung und der Überprüfung der Einhaltung der Selbständigkeitserklärung bzw. der Reglemente betreffend Plagiate erteile ich der Universität Bern das Recht, die dazu erforderlichen Personendaten zu bearbeiten und Nutzungshandlungen vorzunehmen, insbesondere die schriftliche Arbeit zu vervielfältigen und dauerhaft in einer Datenbank zu speichern sowie diese zur Überprüfung von Arbeiten Dritter zu verwenden oder hierzu zur Verfügung zu stellen.

Ort/Datum

Unterschrift

Figure 1.4: Declaration that you have independently written the thesis.

Bibliography A thorough description of the organization and structure of the bibliography follows in Chapter 3.

Declaration of Authorship The thesis must also contain the signed declaration of authorship (“Erklärung” – see Fig. 1.4), in which the candidate confirms that she/he personally authored the work. Print, sign, scan, and include the declaration at the very end of the thesis.

Chapter 2

Language and Structure

2.1 Language

When writing a BSc or MSc thesis, one needs to know the rules of grammar, even the “small” rules about when to capitalize and where to put commas¹. When you deviate from expected rules, you draw the reader’s attention and the reader’s attention is a precious gift that should not be wasted. In academic writing, you want your ideas to receive the attention, not your writing.

For scientific texts, the formal and objective language is the right form. There are no rules for academic style that apply to all situations. The following guidelines might help you to develop your own style.

2.1.1 What to Avoid

When writing, be careful to avoid the following (please double-check your thesis before submitting it).

- Trivial spelling mistakes (e.g. The *resutls* show ...)

¹As a starting point for reading, we suggest the classical book of Strunk and White “*The Elements of Style*” mentioned in Chapter 0 of the present notes.

- Subjective exaggerations (e.g., The results show how *perfectly* the new system works.)
- Meaning-enhancing and subjective terms (e.g., The *many* tests *naturally* led to *very* different results.)
- Casual evaluations (e.g., *Unfortunately*, this approach proved to be *completely pointless*.)
- Expression of personal enthusiasm (e.g., This statement can be *wholeheartedly* agreed with *from the author's point of view*.)
- Adverbs that show your personal attitude (e.g., *luckily*, *remarkably*, *surprisingly*, etc.)
- Personal phrases (e.g., *in my opinion* or *personally*, *I think ...*)
- Colloquialism and platitudes (e.g., *So it came as it had to come* – the algorithm didn't work.)
- Idiomatic or colloquial vocabulary
 - *like* (use *for instance* or *for example*)
 - *lots of* (use *a significant/considerable number* or *numerous*)
 - *little/big* (use *small/large*)
 - *get better/worse* (use *improve/deteriorate*).
 - *good/bad* (use *positive/negative*)
- Filler vocabulary (e.g., Although there *apparently* are proponents of this view, it is not accurate, *so to speak*.)
- Question forms (e.g., *Why does this algorithm not work?*)
- Contracted verb forms (e.g., *don't*, *can't*)

Another aspect that you must absolutely avoid is to include a reflection in your BSc or MSc thesis. Hence, do not describe your erroneous paths – a thesis should *never* read like a travelogue or work log. Even though you might have tried many things in your research that may not have worked, you end up writing the thesis as if you had always planned it that way (you are the *omniscient* writer). That is, the structure of a thesis is very rarely – if ever – a reflection of the chronological events of the underlying research.

Yet, this should not mean that you have to hide negative results in any case. The reporting of negative results can be also valuable for science. For example, one can explain such results in the context of preliminary evaluations and then show what findings and adjustments one has made to actually make the method succeed.

Last but not least, you should also avoid (uncontrolled) redundancy. Repeating an idea or including an irrelevant point, suggests that the writer is not fully in control of the material. It gives the impression that either he does not properly understand the language or is trying to ‘pad’ the text by repeating the same point.

Sometimes, however, redundancy is desirable. For example, a concept that has already been introduced informally (e.g., in the introduction) can be explained again in more detail in a later chapter. In such cases, however, be careful not to copy individual sentences or even entire paragraphs word for word and without modification².

²We will typically read through your work in one breath – if we read the same sentence (or paragraph) identically twice we feel cheated – a bad feeling, and bad feelings lead to bad grades.

2.1.2 Academic Vocabulary

When writing, you should strive for clarity, conciseness, and stringency. Simple vocabulary and simple sentences are particularly effective (as they enhance clarity). That is, avoid long, convoluted, warped, phrases that twist, turn and distract from the point. In particular, do not use long sentences with complex grammar and unusual words just to show that you can. There is also rarely a reason to use synonyms for the same concept — choose a terminology and stick to it. This reduces the mental load on the reader.

In scientific writing you should pay attention to consistency. Never switch between different notations or conventions within your thesis. For some words there are several possible spellings. Once you have decided on a spelling, you should keep it throughout your text and not switch between different options (e.g. *dataset* vs. *data set* vs. *data-set*).

To write academic texts you need to be familiar with the rather formal vocabulary widely used in this area. Students wishing to develop their academic vocabulary should study the *Academic Word List* (AWL). You can try learning some words from the list every day, but it might be better to study the words in context, so that you understand how they are actually used.

AWL was developed by Averil Coxhead at Victoria University of Wellington, New Zealand³. The list contains 570 word families which were selected according to certain principles. These selection principles are:

1. Range: The AWL families have to occur in the Arts, Commerce,

³<https://www.wgtn.ac.nz/lals/resources/academicwordlist/information>

Law and Science faculty of the underlying Academic Corpus.

2. Frequency: The AWL families have to occur over 100 times in the 3,500,000 word Academic Corpus in order to be considered for inclusion in the list.
3. Uniformity of frequency: The AWL families have to occur a minimum of 10 times in each faculty of the Academic Corpus to be considered for inclusion in the list.

Four examples of the 570 word families are as follows (see `awlsublists.pdf` on ILIAS for a complete list)⁴.

- **analyse**: analysed; analyser; analysers; analyses; analysing; *analysis*; analyst; analysts analytic; analytical; analytically; analyze; analyzed; analyzes; analyzing
- **context**: context; contexts; contextual; contextualise; contextualised; contextualising; uncontextualised; contextualize; contextualized; contextualizing; uncontextualized
- **evident**: evidenced; *evidence*; evidential; evidently
- **vary**: invariable; invariably; variability; variable; *variables*; variably; variance variant; variants; variation; variations; varied; varies; varying

The complete word list has been divided into ten sublists based on the frequency of occurrence of the words in the Academic Corpus. There are 60 families in each sublist, except for sublist 10 which consists of 30 word families ($9 \times 60 + 30 = 570$ word families in total).

⁴Each word in italics is the most frequently occurring member of the word family.

The words in sublist 1 occur more frequently in the corpus than the other words in the list. Sublist 2 contains the next most common words, and so on. One can expect that a word from a word family of sublist 1 occurs on every fourth page of an academic text. The words from sublist 10, however, only appear on every eighty-second page (it is assumed that there are 400 running words on a page and these figures are only averages, of course).

The following table, for instance, consists of the most frequently occurring members of the 60 most frequent word families (i.e., the most frequent word per word family stemming from sublist 1):

analysis	definition	indicate	procedure
approach	derived	individual	process
area	distribution	interpretation	required
assessment	economic	involved	research
assume	environment	issues	response
authority	established	labour	role
available	estimate	legal	section
benefit	evidence	legislation	sector
concept	export	major	significant
consistent	factors	method	similar
constitutional	financial	occur	source
context	formula	percent	specific
contract	function	period	structure
create	identified	policy	theory
data	income	principle	variables

2.1.3 Using Verbs and Tenses

Academic writing tends to use rather formal verbs to express the writer's meaning accurately. The following list contains some formal verbs that are frequently used in academic texts.

Accelerate	Compound	Diminish	Insert	Publish
Access	Comprehend	Discriminate	Integrate	Pursue
Achieve	Comprise	Document	Interact	React
Adapt	Concentrate on	Emerge	Interpret	Recognize
Affect	Conclude	Emphasize	Intervene	Refine
Aid	Conduct	Enforce	Invest	Regulate
Allocate	Confine	Envisage	Involve	Reinforce
Alternate	Confirm	Establish	Isolate	Relate
Analyze	Consent	Estimate	Justify	Rely
Approach	Constrain	Evaluate	Legislate	Remove
Argue	Consult	Exhibit	Link	Require
Arise	Consume	Expand	Locate	Respond
Assess	Contract	Facilitate	Maintain	Restore
Assign	Contradict	Focus	Manifest	Restrict
Assist	Contrast	Function	Modify	Retain
Assume	Contribute	Fund	Monitor	Reverse
Attain	Convert	Generate	Obtain	Seek
Attribute	Coordinate	Grant	Occupy	Select
Be concerned	Create	Guide	Occur	Specify
Categorize	Decline	Hold	Overcome	State
Channel	Deduct	Identify	Participate	Submit
Characterize	Define	Illustrate	Perceive	Supplement
Claim	Demonstrate	Implement	Precede	Survey
Clarify	Derive	Imply	Prioritize	Transfer
Classify	Detect	Impose	Process	Undergo
Commit	Deteriorate	Improve	Promote	Validate
Communicate	Determine	Indicate	Propose	Yield
Compensate	Deviate	Inhibit	Prove	

A *phrasal verb* is a verb made up of two or more words: the main verb with an adverb or preposition, or both. Using these words in combination gives them a meaning different from that of the individual words used. This makes them difficult for non-native English speakers to understand.

Some phrasal verbs are too informal for academic writings. Following are few examples of such unsuitable phrasal verbs.

Phrasal Verb	Better Solution
Get up	Rise or Increase
Put into	Contribute
Find out	Discover
Look at	Explore/Research
Look into	Examine
Look out for	Identify
Look up	Verify
Got together	Merge
Bring about	Cause
Cut out	Delete
Come across	Find

However, there are also some acceptable phrasal verbs that you can use when writing academic texts. We recommend, for instance, the use of:

- *carry out*
- *consists of*
- *discussed by*
- *based on*

A difficult and somehow controversial question is in which tense a BSc or MSc thesis should be written. The most important thing is to maintain consistency in the use of tenses in your work. In computer science, it is quite common to consistently write in the present tense. This may seem a bit strange at first glance – but it actually makes some kind of sense (and besides it greatly simplifies the writing process).

Even if you are describing a paper that dates back several years (or decades), you can argue that the paper is still valid (or at least available), which argues for using the present tense:

- Brown et al. [17] *show/prove/validate* in their paper ...

The same is true for descriptions of one's own experiments, methods, figures, etc.:

- The research findings *demonstrate* that ...
- Using the experiments, we can empirically *prove* ...
- The experiment *yields* significant results.
- We first *describe* ..., then we *explain* ...
- Algorithm 17 *uses* ...
- In Fig. 17 we *see* ...
- We first *conduct*
- etc.

Only when describing aspects of the future work, it might make sense to change the tense – but even here this can actually be worked around. For instance, with verb phrases *could be* or *might be* as well as specific verbs as, for instance, *aim to* or *plan to* to express a possibility or potential state of being in future.

- More advanced methods *could be* researched.
- A combination *might be* beneficial as well.
- We *aim to* combine the two methods.
- We *plan to* conduct more exhaustive evaluations.

2.1.4 Other Language Elements

Bullet List Bullet or enumeration lists can be an effective style element for drawing a reader's attention to a set of important statements. However, they are not an excuse for writing abbreviated or sloppy prose. Bullet lists should be punctuated consistently, and you should use a consistent sentence or phrase structure in each item.

Bad Example	Better Solution (i)	Better Solution (ii)
<ul style="list-style-type: none">• First we review the list.• Define the list• The list needs to be made.• List design	<ul style="list-style-type: none">• Review the List• Define the list• Make the list• Design the List	<ul style="list-style-type: none">• Reviewing• Defining• Making• Designing

Abbreviations Abbreviations are an important and expanding feature of contemporary English, widely used for convenience and space-saving. Abbreviations take the form of shortened words, acronyms or other abbreviations:

- *Shortened words* are often used without the writer being aware of the original form. 'Bus' comes from 'omnibus', which is hardly used in modern English. However, 'refrigerator' is still better in written English than the informal 'fridge'.
- *Acronyms* are made up of the initial letters of a name or phrase (e.g., AIDS = Acquired Immune Deficiency Syndrome). They are pronounced as words.
- *Other abbreviations* are read as sets of individual letters. They include names of countries, organisations and companies (USA/

BBC/ IBM).

Some abbreviations are common, e.g., DNA or DVD (note that in many cases abbreviations are widely used without most users knowing what the individual letters stand for). However, writers also employ more specialized abbreviations in texts, which are explained in brackets on first use (e.g., *Starting from the resource-based view (RBV) of the firm, it is argued that ...*).

After introducing an abbreviation, you should use it consistently and not switch between the written version and the abbreviation (e.g., *An electrocardiogram (ECG) was obtained. Yet, the ECG was unremarkable.*). Exception: In order not to disturb the reading flow, abbreviations at the beginning of a sentence are always written out.

Avoid using different abbreviations for the same word. It is best to first check if there is already a given abbreviation for the word in question. This is better than making up your own abbreviation.

The abbreviation *e.g.* means “for example” while *i.e.* means “that is”. Do not mix them up. Both abbreviations are commonly followed by a comma. That is, you should punctuation them as you would the equivalent English phrase. There are abbreviations that have a full stop after them to show that it is a shortened form. There is, however, a tendency to use full stops less. The important thing is to employ a consistent style in your work.

Note that L^AT_EX puts more white space after a “.” This makes sense in the case of a period. Yet, in case “.” is not a period (for example in

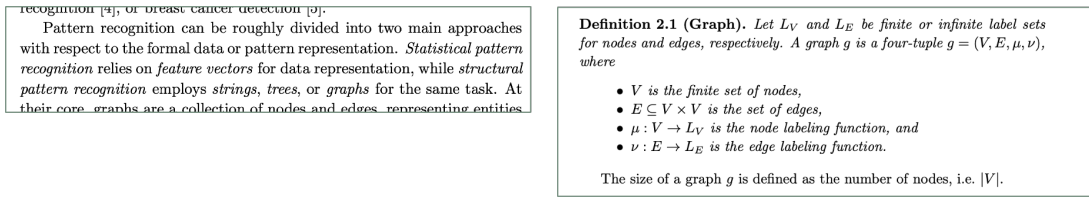


Figure 2.1: Smaller and larger definitions in plain text and in the definition environment of L^AT_EX.

an abbreviation) a normal space should be displayed. We recommend to use the tilde symbol “~” rather than a normal space in such cases.

Definitions Definitions are not needed in every case, but if the writer wants to use a term in a special way, it is important to make clear to the reader exactly what is meant in this context. In general, we differentiate between “small” and “large” definitions. The former are incidentally defined in the plain text and the latter are formally formulated in detail in special L^AT_EX environments (see also Fig. 2.1).

Examples Examples are used in academic writing for support and illustration. Suitable examples can strengthen the argument, and they can also help the reader to understand a point. Generalisations are commonly used to introduce a topic. If the reader is given an example for illustration the idea becomes more concrete: *Many plants and animals are threatened by global warming. Polar bears, for example, are suffering from the lack of Arctic ice.*

Similar to definitions, we can also distinguish between “small” and “large” examples (see also Fig. 2.2)

There are standard formulations for the introduction of examples:

lenges on a daily basis. Face recognition is one of the most prominent examples of human pattern recognition. Every day we distinguish between countless faces and remember faces we may not have seen for years. Understanding language is another example of pattern recognition. We effortlessly decode the symbols and sounds into meaningful sentences, by recognizing patterns in the arrangement of these symbols. The way we understand people's handwriting despite variations in style also demon-

Example 2.1. In Figure 2.1 different kinds of graphs are shown. Different shades of grey refer to different labels.

Figure 2.2: Smaller and larger examples in plain text and in the example environment of L^AT_EX.

- for instance, for example (with commas):
 - *Some car manufacturers, for instance Hyundai, now offer ...*
 - *For example, Hyunday now offers ...*
- such as, e.g.:
 - *Many successful businessmen such as Bill Gates ...*
 - *This can be written at the beginning of the thesis (e.g., in the introduction).*
- particularly, especially (to give a focus):
 - *Certain Masters courses, especially American ones, take ...*
 - *In particular, American courses ...*

2.2 Structure

A good division of the chapters into sections and paragraphs is crucial for the readability of the thesis.

Before starting the actual writing, the structuring should be discussed with the supervisor – a skeleton of the thesis, showing the division into sections and subsections, and also indicating for each section the core sentences (see below) that will be covered in that section by means of paragraphs, serves as the basis for this discussion.

Chapter 3

Graph Neural Networks

This chapter serves as an introduction to graph neural networks (GNNs). In section 3.1 an overview of the different approaches to GNNs is given and the message-passing framework is introduced. In section 3.2 different GNN models are reviewed. First, the most well-known models are introduced, and an example GNN model is analysed to bridge the gap between graph convolution and MLPs. Later GNNs specifically designed for graph classification tasks are described in more detail.

3.1 Approaches

Wu et al. provide an overview of different GNN approaches and implementations [8].

~~They describe the research on GNNs as having become one of the fastest-growing~~

Figure 2.3: A good preamble helps the reader to find their way around your work.

2.2.1 Rules for Sections

You have to capitalize the word *section* when you use it together with a concrete numbering (and otherwise not):

- *In Section 1.4 this method is described in more detail.*
- *This is described in more detail in the subsequent section.*

In the final thesis, we recommend to briefly outline the main sections at the beginning of each chapter in a preamble and explain what is discussed in that chapter (you want to help the reader not to lose the thread – see Fig. 2.3 for an example of such a preamble).

Each section and subsection discusses a specific topic and needs a descriptive/informative name (section and subsection titles should fit on a single line). The use of informative titles help readers to know exactly what follows and where to look up specific information. Always capitalize the first word as well as all nouns, pronouns, verbs, adjec-

tives, and adverbs in titles (e.g., *The Old Man and the Sea*).

Outline sections include at least two separate sections, i.e., Section 2.1, for instance, has to be followed by at least Section 2.2. The hierarchy of sections should be limited to three levels.

One uses sections when there are more than two subtopics in a chapter which are best explained independently. Vice versa, one does not use sections and subsections if there are no subtopics in the text, e.g., if the text is very short or the subtopics are strongly related with each other or one does not want to interrupt the reading flow.

2.2.2 Rules for Paragraphs

Paragraphs are the basic building blocks of academic writing. Within one paragraph, one explains one specific core idea, thought or consideration that belongs to an overarching topic (of the corresponding chapter or section).

One can only write a good paragraph if one knows the core idea of this paragraph (try to internalize this one-to-one relationship: 1 core idea = 1 paragraph). That is, one needs to know what one wants to accomplish with the paragraph.

- Give an example?
- Make a clear point and elaborate on it?
- Explain a cause or consequence?
- Introduce an algorithm?

- Describe advantages and/or drawbacks of a method?
- Discuss a table or a figure?
- Draw conclusions from an experiment?
- etc.

Once one knows what to accomplish with the paragraph, e.g., describe the positive effect of a certain procedure, one can write down one to three *core sentences* of the paragraph (this can also be accomplished with shorthand notes).

Well-structured paragraphs help the reader understand the topic more easily by dividing up the argument into convenient parts. The length of paragraphs varies significantly according to text type, but should be no less than four or five sentences. Normally (but not always) the first sentence *introduces* the topic. Other sentences may give

- definitions, examples, information, reasons, restatements and summaries.

(**Topic**) *The rate of home ownership varies widely across the developed world. (Example 1) Germany, for instance, has one of the lowest rates, at 42 per cent, while in Spain it is twice as high, 85 per cent. (Example 2) Both the USA and Britain have similar rates of about 69 per cent. (Reason) The reasons for this variation appear to be more cultural and historic than economic, since high rates are found in both rich and poorer countries. (Summary) There appears to be no conclusive link between national prosperity and the number of homeowners.*

Paragraphs always start at a new line and are typically linked to the previous paragraph. Good links between your paragraphs make it clear what you are doing and so they make it easier for your reader to follow your writing. A paragraph link (also known as a “transition” or “bridge”) is a way of having a natural flow between two paragraphs so that the reader can easily follow your thread.

There are many ways in which a paragraph can be linked to the contents of the directly (or indirectly) preceding paragraph.

- Linking can be done by means of demonstrative pronouns referencing something described in the previous paragraph (often by means of *this* or *these*).
 - This idea/interpretation/algorithm/etc.
 - These ideas/interpretations/algorithms/etc.
- Linking can be done by means of linking words. It is important to choose a linking word that fits very well, as different words show either *addition*, *contrast*, or *consequence*.
 - Present a further algorithm to the one detailed in the previous paragraph (then, for example, *Additionally* would fit)
 - Explain a counter-argument to the rationale explained in the previous paragraph (then *On the other hand* fits well)
 - Draw a conclusion from the findings of the previous paragraph (then *Consequently* might be a good choice).

Below you find alternatives for all three categories.

Additionally	On the other hand	Consequently
Additionally, ...	A contrary explanation is ...	As a consequence, ...
Also ...	Although, ...	Accordingly, ...
An equally significant aspect is ...	But ...	As a result, ...
Another important factor is ...	Conversely, ...	As we have seen, ...
Furthermore, ...	Despite this, ...	Consequently, ...
In addition to, ...	However, ...	Due to ...
Last but not least, ...	In contrast, ...	For this reason, ...
Moreover, ...	Nevertheless, ...	Hence, ...
Particularly, ...	On the other hand, ...	Subsequently, ...
Second, ... Third, ...	Otherwise, ...	Therefore, ...
Similarly, ...	Yet, ...	Thus, ...

- Linking can also be done by *Signposting*. Signposting is when you use a phrase that explicitly tells the reader what you provide in this paragraph. For example:

- Previewing a topic (e.g., *The next paragraph describes ...*)
- Returning to a topic (e.g., *As explained earlier, ...*)
- Starting a topic (e.g., *Moving on now to ...*)
- Summarizing a topic (e.g., *So far, this section has reviewed the three key aspects of ...*)

Chapter 3

Citing and Describing

3.1 Citing

3.1.1 Plagiarism

Academic writing depends on research and ideas of others. Hence, it is vital to show which sources you have used in your work in an acceptable manner. This can be done by means of *citations* and *references*. Citations are the short codes you include in the written text (e.g., numbers or names in brackets), while references refer to the full details of the source you have cited in your writing (see Fig. 3.1).

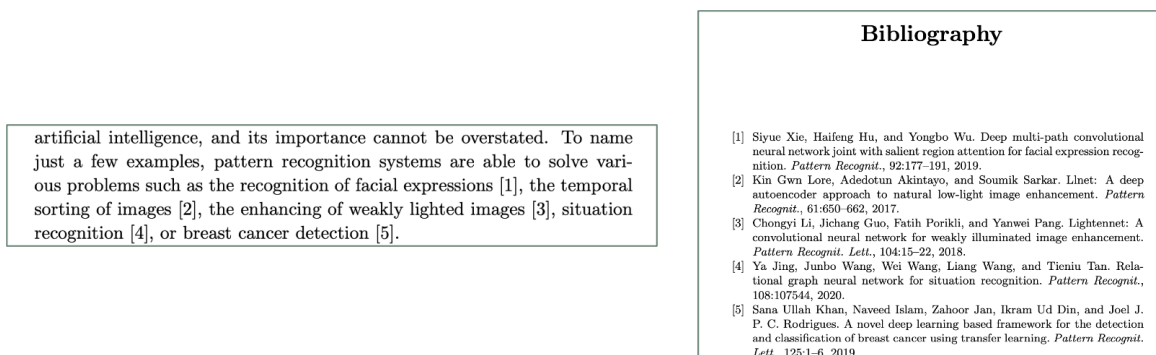


Figure 3.1: Citations are, for instance, numbers in the written text and the bibliography is a list of all references cited in the writing.

There are actually three principal reasons for providing references and citations:

1. To show that you have read some of the authorities on the subject, which will give added weight to your writing.
2. To allow the reader to find the source, if he/she wishes to examine the topic in more detail.
3. To avoid *plagiarism*.

In academic work, ideas and words are seen as private property belonging to the person who first thought or wrote them. Basically plagiarism means taking ideas or words from a source without giving credit (acknowledgement) to the author. It is seen as an "academic crime" (in this sense, you are reading a very bad example – the present notes are largely copied passages from the two books mentioned at the beginning of the notes¹ without academically valid citations).

There are several reasons why students must avoid plagiarism:

- To show that you understand the rules of academic writing.
- To develop your own understanding of the material.
- To avoid being found out as plagiarist (easily detected by software) and therefore not failing the course or even having to leave the university.

¹

- Bailey, Stephen. Academic writing: A handbook for international students. Routledge, 2014.
- Strunk, William, E. B. White,. The Elements of Style. SWB Books, 1918.

It is not a good excuse to say that you did not know the rules of plagiarism, or that you did not have time to write in your own words. In general, anything that is not common knowledge or your own ideas and research (published or not) must be cited and referenced.

However, it can be difficult to decide what is general or common knowledge. The other main difficulty that students face is that they are expected...

- ...to show that they have read the principal experts on a subject — by giving citations
- ...to explain these ideas in their own words and come to their own original conclusions

3.1.2 Citing

There are various systems of citing in use in the academic world. They typically use one of three basic approaches:

- parenthetical citations
- numerical citations
- note citations

In our template we use a numerical system, viz. the *Vancouver system*: Numbers in square brackets are inserted after the citation and these link to a numbered list of references at the end of the main text (known as *Bibliography* – details follow in the next subsection). With L^AT_EX citing is straightforward by using the `cite{...}` command (→ use the templates).

A citation is an annotation for a sentence. It is not part of the sentence and should play no grammatical role in the sentence. In other words, if you remove the citation, the sentence should still be grammatically correct and complete.

- Bad example: As it is reported in [17]...
- Better: Smith [17] reports that...

Please avoid sets of references (e.g., *Many researchers have studied these normal forms [17-22].*) It should be clear to the reader why you are citing a work and what connection it has to your work.

Note: In L^AT_EX the tilde symbol has the same semantics as a space except it prevents a line break. So we recommend using tilde (instead of a space) before a citation (in order to prevent a line break directly before citation).

3.1.3 Paraphrasing and Summarizing

In order to acknowledge and cite others' work, you can use a quotation and give a reference to the original source:

- *According to Smith: "The point is not that the state is in retreat but that it is developing new forms of power." [17].*

In this case it is clear to the reader that you have read Smith and borrowed this idea from him.

Often, quotations are introduced by a phrase that shows the source, and also explains how this quotation fits into your argument:

- *As James [17] remarked "Martin's concept of internal space requires close analysis."*

Using a quotation brings the original words of a writer into your work. They can be valuable...

- ...when the original words express an idea in a distinctive way
- ...when the original is more concise than your summary could be
- ...when the original version is well-known

Quotations are effective in some situations, but must not be over-used. Moreover, you should avoid too long quotations.

This brings us to the more often used options to provide a correct acknowledgement, viz. by means of paraphrasing and summarizing. Actually, with paraphrases and summaries you can include other writer's ideas in your work and simultaneously demonstrate your understanding of a text.

- *Paraphrasing* involves re-writing a text so that the language is substantially different while the content stays the same.
- *Summarizing* means reducing the length of a text but retaining the main points.

Paraphrasing and summarizing are normally used together in academic writing, but while summarizing aims to reduce information to a suitable length, paraphrasing attempts to restate the relevant information.

Effective paraphrasing is a key academic skill needed to avoid the risk of plagiarism: it demonstrates your understanding of a source.

Effective paraphrase usually...

- ... has a different structure to the original
- ... has mainly different vocabulary
- ... retains the same meaning
- ... keeps some phrases from the original that are in common use

Techniques for paraphrasing:

- Changing vocabulary by using synonyms. Yet, do not attempt to paraphrase every word, since some have no true synonym.
- Changing word class, e.g., explanation (n.) → explain (v.) / mechanical (adj.) → mechanize (v.) / profitable (adj.) → profitability (n.)
- Changing word order, e.g., *...the best explanation for the British location of the industrial revolution is found by studying demand factors.* → *A focus on demand may help explain the UK origin of the industrial revolution...*

Summarizing is also a vital skill in academic writing, allowing the writer to condense lengthy sources into a concise form. A good summary requires:

- selection of most important aspects
- clear description
- accuracy

Possible Process for summarizing:

- Read the original text carefully and check any new or difficult vocabulary.
- Mark the key points by underlining or highlighting.
- Make notes of the key points, paraphrase where possible.
- Write the summary from your notes, re-organize the structure if needed.
- Check the summary to ensure it is accurate and nothing important has been changed or lost.

Make sure that you use impersonal phrases in both paraphrasing and summarizing.

- *It is generally accepted that ...*
- *It is widely agreed that ...*
- *It is probable that ...*

Use the following phrases to suggest a minority viewpoint:

- *It can be argued that ...*
- *One view is that ...*
- *Another opinion is that ...*

When including summaries and paraphrases (and also in quotations), sometimes one includes the name of the author of the original source within the sentence. In order to do this, *referring verbs* can be used. The verb *report* is probably one of the most commonly used referring verbs.

- *Abrams [17] reports that . . .*

Instead of using the rather neutral referring verb *report*, one can use others. For instance:

Agrees	Emphasises	Points out
Articulates	Explains	Proves
Assumes	Finds	Refutes
Believes	Highlights	Remarks
Claims	Identifies	Reports
Clarifies	Illuminates	Reveals
Concludes	Illustrates	Shows
Confirms	Insists	States
Demonstrates	Justifies	Supports
Denies	Mentions	Suggests
Describes	Observes	Uncovers
Discusses	Outlines	Verifies

When there are three or more authors of a reference, you should use the abbreviation *et al.*, derived from the Latin term "et alia", which means "and others" (typically *et al.* is printed in italics):

- *According to Hobolt et al. [2], many Americans fail to vote.*

Note, however, that the full list of names must be given in the reference in the bibliography.

3.1.4 The Bibliography

At the end of thesis there must be a list of all references cited in the writing – known as *bibliography*. The references give the reader the necessary information to find the source if the reader needs more detail. We strongly recommend to use BibTex to define the bibliography.

The provided templates automatically compile the bibliography based on the citations used in the written part of your thesis. In the Vancouver system (used in the templates), the bibliography is organized

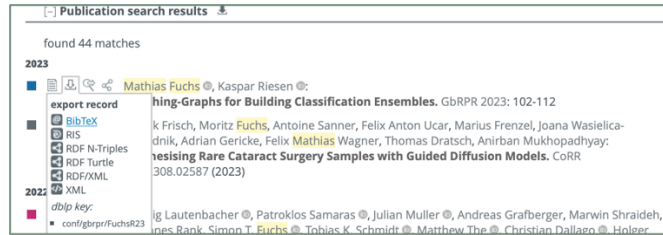


Figure 3.2: On <https://dblp.org> one can download BibTeX records of papers.

so that the order of references corresponds to the order of citations in the text.

To make the references consistent (e.g. *Pattern Recognition Letters* vs. *Pat. Recognit. Lett.* vs. *PRL*), we strongly recommend to choose a platform (and stick to it) from which one can find and load the vast majority of the references actually cited in the thesis as BibTeX records (we recommend to use <https://dblp.org> – see Fig. 3.2). References that one does not find on the chosen platform, should be carefully defined such that they match the style and level of detail of the other references.

As a very rough guideline for the number of references in the bibliography, the page length of the thesis can be considered, i.e., if the topic is discussed on 25 pages, the bibliography should consist of approximately 25 references.

Finding relevant papers is as much art as it is science. The following procedure can be helpful.

- First understand how your field is organized (use Wikipedia or similar).
- Second, locate survey papers. They provide an introduction to

the topic and summarize the most seminal papers that are published in that area.

- Make a list of authors, datasets, and methods.
- In addition, you should also try to find relevant research groups, conferences and journals.
- Third, search with the keywords from the list of step 2 on `dblp.org` or `scholar.google.ch` or similar.
 - Identify the top cited papers.
 - Use a forward citation search to find other relevant papers.
 - Browse profile pages of relevant authors to explore other publications and co-authors.

Note: We recommend that you do *not* include any references to websites in the bibliography, or if you do, then only very few.

3.2 Describing

3.2.1 Basic Comparisons

It is often necessary to make comparisons in academic writing. It is important to explain clearly what is being compared and to make the comparison as accurate as possible.

The two basic comparative forms are:

- *-er* is added to one-syllable adjectives and two-syllable adjectives ending in *-y*, which changes into an *i*
 - France is *larger* than Switzerland.

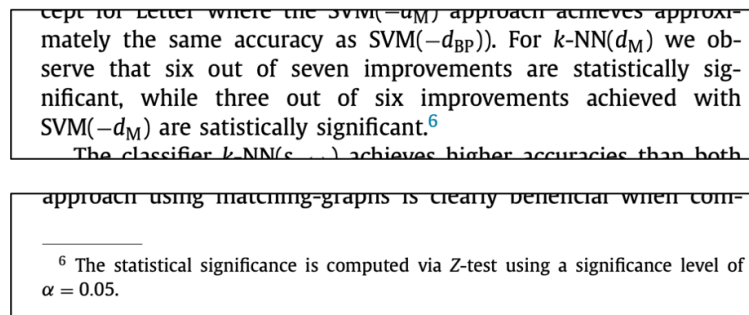


Figure 3.3: If you report *statistically* significant differences, a statistical test must be performed and specified.

- The students were *happier* after the exam.
- *more...* is used with other adjectives of two or more syllables
 - Learning Chinese is *more* difficult than learning English.

Comparisons can be modified using adverbs such as

- slightly
- considerably
- significantly
- substantially

For example:

- France is *substantially* larger than Switzerland.
- Switzerland is *slightly* smaller than Holland.
- Winters in Poland are *significantly* colder than in Portugal.

If you claim *statistical* significance, a suitable statistical test must be performed and the parameters (confidence level) of the test must be specified (see Fig. 3.3).

Similarity can be noted using *as ... as* or *the same as*:

- The population of France is *the same as* the population of Britain.
- Summers in Tokyo are *as wet as* in Singapore.

The forms *twice as ... as*, *ten times as ... as*, etc. can also be used for quantitative comparisons:

- Britain is *half as large as* France.

When using superlatives take care to define the reference group. For instance, *the cheapest car* has no meaning – use *the cheapest car in the Ford range* instead.

Note that *the most/the least* are followed by an adjective:

- *The most interesting example is Ireland.*

The most/the fewest can also be used in relation to numbers:

- *The fewest students studied biogenetics.*

3.2.2 Generalizations

Generalizations give a simple picture of a topic and are easy to understand. The writer must decide when accuracy is necessary, and when a generalization is acceptable.

- Easy to understand: *The majority of smokers in Britain are women.*
- Higher Accuracy: *Of all smokers in the UK, 56.2 percent are women and 43.8 percent are men.*

Generalizations can be made in two ways:

1. Using the plural:

- *Computers* have transformed the way we live.

2. Using the singular + the:

- *The computer* has transformed the way we live.

Avoid generalizations that cannot be supported by evidence or research, or, more generally, avoid absolute phrases at all (such as *Crime is linked to poor education*). Such statements are dangerous because there may well be exceptions. A cautious style is necessary to avoid making statements that can be contradicted.

Caution can be shown in several ways:

- Crime *may/can/might be* linked to poor education. (*modal verb*)
- Crime is *frequently/usually/mostly/generally/slightly/etc.* linked to poor education. (*adverb*)
- Crime *tends* to be linked to poor education. (*verb*)

Another way to express caution is to use *quite*, *rather* or *fairly* before an adjective (*quite* is generally used positively, while *rather* tends to be used negatively).

- a *fairly* accurate summary
- a *rather* inconvenient location
- *quite* a significant discovery

Besides the situation of generalizations, one must also use tentative language in other situations. Other areas where caution is particularly important include:

- outlining a hypothesis that needs to be tested
- discussing the results of a study, which may not be conclusive
- commenting on the work of others
- making predictions
- drawing conclusions

3.2.3 Language of Numbers

Numbers are often used to give an account of a situation. For instance:

- Approximately 1,800 children between the ages of five and 12 years are randomly selected².
- The earth's atmosphere appears to be gaining 3.3 billion metric tons of carbon annually.
- ...but five winters in the twentieth century were more than 2.4°C colder than average.

There is no final 's' on hundred/thousand/million used in combination with numbers:

- Six million people live there.
- Millions of people live there.

It is normal to write whole numbers as words from one to ten and as digits above ten:

- *Five* people normally work in the cafe, but at peak times this can rise to *14*.

²In English, one uses commas (not inverted commas!) to separate numbers greater than 999. We use a comma every third digit from the right: *More than 1,500,000 people turned up to protest.*

Rates are normally expressed as percentages:

- The literacy rate rose to 75%.

Percentages are commonly used for expressing degrees of change. Note the difference between *percentage* and *percentage points* (the former means one hundredth of something, while the latter is used when comparing percentages to one another).

For example, when inflation drops from three to two percent, this means that...

- ...inflation decreases by one percentage point.
- ...inflation decreases by 33.3%.

Sometimes one wants to rephrase percentages:

Percent	Rephrasing
- 5%	tiny minority
5–20%	small minority
21–39%	minority
40–49%	substantial/significant minority
51–55%	small majority
56–79%	majority
80–95%	large majority
95% +	vast majority

Although the accurate use of numbers is vital, too many statistics can make texts difficult to read. If the actual number is not important, words such as *few*, *several*, *various*, *dozens*, or *scores* may be used instead.

The following expressions can also be used to present and simplify statistical information:

Expression	Example
one in x	one in three engineering students is from China
twice/three times as many	twice as many women as men study business law
a five/tenfold increase	there was a fivefold increase in the price of oil
to double/halve	the rate of infection halved after 2001
the highest lowest	the lowest rate of home ownership was in Germany
a quarter/fifth	a fifth of all employees leave every year
the majority/minority	the majority of births are in hospital
on average, the average	on average, each judge hears two cases per day
a small/large proportion	the website generates a large proportion of their sales

3.2.4 Visual Information

Visuals – that is figures and tables – are a convenient way of displaying large quantities of information in a form that is easy to understand. Actually, readers of BSc or MSc theses sometimes directly scroll to the tables and figures before reading the entire text. So, the tables need to be well organized and self-explanatory.

- Titles should be concise and describe the purpose and content of the table or figure.
- The caption should also be concise and draw the reader’s attention towards the key findings of the research.
- Column heads, axis labels, figure labels, etc., should also be appropriately labeled.

Additionally, make sure that the tables are easy to read and neatly formatted (L^AT_EX offers countless possibilities for this – consult, for instance, the wikibook *LaTeX/Tables* for more information).

With scans or screenshots of images, the question of copyright is sensitive. It is thus best to use figures and images that you have created yourself (note, however, that redrawing an existing figure does not

solve the copyright problem. It is still mandatory to cite the source of the original figure).

Make sure that figures are displayed at a high resolution. All parts of the figure should be clear. Ensure the use of a standard font, and legible labels. Use appropriate legends as they make figures effective and draw attention towards the key message. Pay extra attention to make figures precise: There should be...

- ...correct use of scale bars in images and maps.
- ...appropriate units wherever required.
- ...adequate labels and legends.

We strongly advise *against* using Excel for plotting data and results. Please use **GnuPlot**, **Matplotlib**, **Seaborn**, or similar.

Although visuals do largely speak for themselves, it is common to help the reader interpret. It is important that you reference and describe all tables and figure in your text. To this end, use the \LaTeX commands `ref` and `label`. When referencing, you must capitalize the words figure and table (e.g., *In Figure 17 one observes...* or *In Table 17 we report...*). Be consistent: either use the words written in full (Figure/Table) or the abbreviations (Fig./Tab.) but do not mix the two forms.

The following two points must be considered and clearly separated when describing a visual:

1. Start with a general description of the structure of the visual (what information is visible in general):

- Figure/Table 17 shows/illustrates/displays...
- In Figure/Table 17 we show/illustrate/display...

Be precise, but at the same time make sure that you do *not yet* describe any results, but only explain the structure of the visual.

- What do the x and y axes mean?
 - What is in the rows, what is in the columns?
 - How to read the table/chart/diagram?
2. Then continue by commenting on the main results shown in the visuals, i.e., give an overview of the most important features of the visible information.
- In terms of accuracy, the new system outperforms the reference system in all but one case.
 - Regarding the run time, we observe a significant decrease of our novel method with $n > 13$.

Often one describes changes in visuals.

- Average temperatures *rose steadily* until 2006 and then *dropped slightly*.
- There was a *sharp decrease* in sales during the summer and then a *gradual rise*.

Use the following vocabulary:

- rise, increase, climb, peak (for increasing values)
- level of, flatten, stabilize (for flattening values)
- drop, fall, decrease, decline (for decreasing values)

- slightly, gradually, steadily, sharply, heavily, substantially, etc.
(for describing the magnitude of the rise or fall)
- You can also use adjectives and nouns: a slight drop, a gradual fall, a sharp decrease, a steady decline, a broad peak, a narrow plateau, etc.

Divide your observations into paragraphs about different aspects of the data. Do not use your own general knowledge to give reasons for the data or to add more information than is shown. The task only requires you to summarize and report the data in the visual.

Be selective and choose the key observations and trends. You do not have to write about every single detail. That is, avoid repetition: Tables and figures add clarity to the research and they complement the research text. They can be used to highlight the main points of your findings, but values should not be repeated in the written text as it defeats the very purpose of these elements.

Use a variety of wordings for:

- Stating what you are referring to:
 - *In terms of ..., Regarding ..., Looking at ..., Turning to ...*
- Making comparisons
 - *slightly more than, by far the highest, as ... as, compared to, double the number of, ... outperforms ...*
- Approximating
 - *nearly, roughly, almost, **about**, etc.*

Pay extra attention to consistency: There should be consistency in both the values and labels used in the visuals and values and labels in the written text. The smallest inconsistencies in the labels or values can lead to great confusion.