Writing About Research

Justin Zobel

University of Melbourne, Australia

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Overview

Choosing the content.

Standard structure considered.

How a thesis (or paper) gets written.

Good writing style.

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Why write a thesis?

Communicate new ideas:

- ▶ Review basic concepts.
- ▶ Explain the ideas and why they are interesting.
- ▶ Describe and justify hypothesis, and explain its implications.
- ▶ Critical history (not a catalogue) of the area.
- ▶ Contrast with work of others – similarities and differences.

Report and record the research:

- ▶ Define fundamentals.
- ▶ Describe experimental method or the structure of the results.
- ▶ Show results and proofs.
- ▶ Critically analyze the outcomes.

Why write a thesis? . . .

The writing of a thesis, or paper, begins at the same time as the planning of the research.

The only outcome of research is the writing; so all activity should be directed towards producing the writing.

The 'start at the end' model of research:

- ▶ How will the thesis be structured?
- ▶ What do you plan to report?
- ▶ What is the sequence of actions that will lead to this planned thesis being complete?

The data you gather, the code you write, the experiments you run, the equipment you build, etc., should be designed solely to complete the thesis.

Content

A thesis or paper should be a clear statement of new knowledge.

What does the reader need?

- ▶ To understand the main result.
- ▶ To know what makes the result useful, new, distinct.
- ▶ To reproduce experiments and re-gather data – verification and application.
- ▶ To have proof of claims and theorems.

Theses should meet these needs, and include nothing else.

Expect skepticism

Readers – including referees and examiners – tend to trust work that is already published in preference to new work.

('Most Published Research Findings Are False'.)

You are excited about your ideas and results; will the reader be?

This means that a paper must be persuasive:

- ▶ Examiners are the jury who decides a thesis's fate.
- ▶ The written thesis is the one chance to persuade them to accept the ideas (and acknowledge the merit of the author) before they deliver a verdict.
- ▶ Thus the evidence and arguments must be complete and convincing.

Examiners may only have hours to assess the work. How will they spend that time?

Hierarchical, not linear, to accommodate different kinds of readers:

- ▶ Not interested – discard quickly.
- ▶ Curious – want main idea.
- ▶ In general area – want results.
- ▶ In specific area – must understand detail.

Most theses and papers are written for the last class, most readers are in the first class.

Use of a standard structure allows readers to readily navigate the work.

Components . . .

Standard components (not necessarily headings) are:

- ► Abstract & other front matter.
- ► Introduction.
- ► Background & literature review.
- ► Contribution.
- ► Results and analysis.
- ► Discussion.
- ► Conclusion.
- ► Bibliography & appendices.

Each has its own challenges.

Components . . .

A strong thesis or paper has a story-like flow.

Think of the thesis as a narrative, a conversation, or a structured explanation – not just a collection of information and results.

- ▶ The first parts of the thesis teach the reader the things they need to understand for the later parts.
- ▶ Information that isn't a natural part of the narrative should probably be left out.

Front matter

Title, author & supervisors (authors, for a paper), affiliation, addresses, date.

Abstract:

- 50–200 words for a paper; 200–400 words for a thesis.
- Concise, precise, specific.
- Statement of main aim and result.
- Self-contained, written in accessible language.

Acknowledgements. (In a paper, these would follow the conclusions.)

Front matter . . .

Use the opening sentence or paragraph of the abstract to establish the topic area.

No: Mechanisms for face detection are unreliable if lighting is dim.

– Does not indicate what the topic of the report is.

Yes: Current digital cameras use face detection to help determine focus and exposure settings. However, mechanisms for face detection are unreliable if lighting is dim.

– Gives some context and establishes that the topic is digital photography.

Some text is observational (cameras use face detection . . .), other text provides a judgement (mechanisms are unreliable . . .). Judgemental statements are not suitable for opening a discussion.

Front matter . . .

The five elements of an abstract:

- ▶ A general statement introducing broad research area of the topic being investigated.
- ▶ An explanation of the specific problem to be solved.
- ▶ A brief review of existing standards or solutions to the problem.
- ▶ An outline of proposed new solution.
- ▶ A summary of how the proposed solution was evaluated, and what the outcomes were.

The tone is of a brief explanation to a knowledgeable friend.

Introduction

Typically written in a conversational style, to:

- ▶ Motivate interest in the work.
- ▶ Establish a single overarching aim for the research.
- ▶ State an explicit hypothesis – of what it is you are testing.
- ▶ Engage the reader with intuitive explanations of the work.
- ▶ For a thesis with multiple contributions, link these together.

A successful introduction is an essay-like report on your aim, research question, approach, and outcomes.

That is, the introduction is a narrative, not a sequence of statements under rigid headings.

Introduction . . .

Should include:

- ▶ Description of the area and topic.
- ▶ Why the topic is interesting.
- ▶ A brief summary of the background.
- ▶ One-sentence overviews of key papers.
- ▶ The hypothesis.
- ▶ A synopsis of results, methods, and outcomes.
- ▶ Ramifications.

Should omit: detail, jargon, mathematics.

Introduction . . .

By the end of the introduction, the reader should understand the *scope* of the work.

For example, if the topic is 'mechanisms for collaborative authoring', then:

▶ Who is doing the authoring? What abilities and experience can they be assumed to have?

▶ What constraints are they working under?

▶ What kinds of tasks are they trying to complete?

▶ How sophisticated do the mechanisms need to be?

(Whether this is already a 'solved problem' is a separate, but important, question.)

Background

A guided tour of your topic. The background introduces the reader to:

- ▶ The state of the art.
- ▶ The failings of the state of the art. Are the limitations of previous approaches obvious?
- ▶ Why the problem is interesting. Is it clear that there is a problem to solve?
- ▶ The technologies or concepts the paper's contribution are based on, that is, knowledge on which your new work builds.
- ▶ Benchmarks or baselines the contribution should be compared to, that is, knowledge that your new work extends or corrects.
- ▶ What other people have said about the same problem.

The background should incorporate most of the literature review.

Literature review

Identifies highlights of previous work: all relevant readings, with explanations of their contributions, results, and shortcomings.

These papers need to be described in a cohesive way, typically by gathering papers into subgroups of related research as well as explaining underlying ideas.

Variations in terminology needs to be unified.

In a longer thesis, each 'contribution' chapter may have a structure like that of a paper, with introductory material and a summary – but a separate literature review may be unnecessary.

Your examiner may not know some of the past work – your thesis may be where she or he is introduced to this material.
Do not treat the background as an essay that is just an exercise to be undertaken for the sake of it!

Contribution

What the 'discovery' of the thesis is – the core idea that the examiners need to appreciate as novel and important.

What the properties of this contribution are: what characteristics it is expected to display, what makes it interesting and plausible.

These aspects should lead into explanation of method and approach:

► How you will investigate and test the validity of your contribution.

► Why the method is appropriate.

('Method' is considered further in another lecture.)

Contribution . . .

Each chapter and section should be long enough to present an argument or explanation, but needs to be limited to a single clear thread of ideas.

Include:

- ▶ Definitions and assumptions.
- ▶ Algorithms, mechanisms, instruments.
- ▶ Statements concerning approach and perspective.
- ▶ Description of test data.
- ▶ Description of experimental methods.

Results

The results chapter is an assembly of evidence on which the key *arguments* will be based.

- ▶ Presentations of experimental outcomes.
- ▶ Theorems, proofs.
- ▶ Numerical analyses of data.
- ▶ Tabulations of investigative outcomes and discoveries.

The program of research will have led to a body of results – millions of data points in some cases.

- ▶ You need to record and maintain these results in a durable, systematic, and responsible way.
- ▶ The material shown in your thesis is chosen to reflect and summarize the complete body of results – fairly, and without bias! – but may only be a small sample of the total body of results you have collected.

Results . . .

Readers needs to know:

▶ How the data was gathered.

▶ How they might obtain or create the data for themselves.

▶ What the 'shape' of the results is.

▶ Background on issues such as known gaps in or limitations of the data.

▶ What the results mean – that is, they need to be explained, analysed, and interpreted.

Results . . .

Omit unnecessary detail:

- ▶ Too many graphs.
- ▶ Secondary proofs.
- ▶ Programs, transcripts, logs.
- ▶ Raw data, records.

Project logs can be used to record information not included in the thesis itself.

Some material may belong in an appendix.

Analysis & discussion

The discussion provides the framework for the conclusions. This is where the aim, question, and results are linked by a clear, logical argument.

Also consider the work discussed in the literature review.

- ▶ How do your results impact on conclusions drawn in previous work?
- ▶ How might any contradictions between your results and previous work be resolved?

Critical analysis is essential!

- ▶ You must question your results just as if you were an independent observer.
- ▶ Assess your research as a complete piece of work.

Conclusions

- Main results – draw together themes.
- Implications of results.
- Limitations of results.
- Avenues for further research.

That is, the conclusions are more than just a list of accomplishments and outcomes.

Back matter

Bibliography:

- ▶ List of articles referred to in the paper.
- ▶ Enduring academic material that is accessible to likely readers.
- ▶ Provide sufficient detail.

Appendices:

- ▶ Detail of proofs, detailed experimental results, extended tables of data.
- ▶ Code (if brief and exemplary) for tricky algorithms.

Papers rarely need appendices; but they are often valuable for theses.

Citation and attribution

Cite to support claims.

Don't cite to pad the bibliography. Read it if you have cited it.

Appraise other people's work fairly.

Use a sensible citation style that is meaningful to the reader.

Your thesis should consist of your own words.

► Don't reuse other people's text (or your own), or close restatements of it.

► Quote to bring in important statements from elsewhere.

► Quotes should only make up a small fraction of your text.

Poor or patchy bibliographies are a sure sign of sloppy research.

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Writing is research

Sketch the thesis at the start of the degree, use it to structure the research so as to progressively fill in gaps.

From the start: use your writing to eliminate ambiguity. A clear problem statement ensures that you have a common basis of understanding with your supervisor and colleagues.

Make sure that you are not sitting on both sides of the fence.

Make explicit:

► What is proposed; what your question is.

► How it will be evaluated.

► What the argument (thread of reasoning) will be.

Writing is research . . .

Propose in detail a methodology for testing your hypothesis:

- Use case study, proof, modelling, simulation, or experiment; or any of these elements in combination.
- Aim to convince the reader – use a persuasive form of test.

Readers should be able to see how they might get similar outcomes without 'undue inventiveness'.

But the same apparatus (machine, software, test data, test subjects . . .) is not usually available to others.

'Roughly speaking, no one ever repeats an experiment.'

However, if the hypothesis is interesting it should be independent of the transient aspects of the methodology.

Remember: a collection of data or a piece of software is not a research outcome.

Writing is research . . .

Write critical sections while there is ample time to do more research. The process of writing often shows where more work is needed:

- ▶ Definition of basics → find that concepts are not clear
- ▶ Abstract description of an algorithm → can see an optimization
- ▶ Outline of a data-gathering process → biases become obvious
- ▶ Mathematical analysis → a difficult proof is needed
- ▶ Graph of results → need more data; or the data is inconsistent

Creating a thesis

Find a well-written theses that presents a similar kind of idea or result, then imitate its structure.

Criticize the structure first. For example,

► Is the ordering reasonable (of chapters and within sections)?

► Are sections meaningfully linked together?

► How detailed is the literature review?

► Is there a non-technical introduction?

Creating a thesis . . .

Write the introduction first: describe area, problems to solve, expected form of results, intended structure of paper.

Sketch out the rest: chapter and section headings, lists of points in each section, lists of references.

Carefully define the basics.

Start work on the literature review; frequently add to it.

Sketch the method, data, algorithms, experiments.

Outline the results, brainstorm the discussion.

Set aside time every day to add to the thesis and fill any holes.

Write conclusions, thoroughly revise introduction and abstract.

Revise, revise, revise, . . . ; edit for flow, style, and layout.

Creating a longer thesis

A minor thesis is much like a paper in scope and structure, except that the examiner should focus on the student rather than the results (more on this later).

In a longer thesis, each chapter can be as rich as a paper.

- ▶ Expect to write the chapters separately.
- ▶ Drafting of the technical chapters that contain the contribution tends to be relatively easy.
- ▶ The hardest part is usually the background and literature review. The volume of careful reading can be an obstacle, as is the need to write succinctly about other people's work. Finish it first, and it will seem as if the main task of writing the thesis is complete.
- ▶ The next hardest can be the introduction. A conversational, natural writing style can take many revisions.

Creating a longer thesis …

Expect to start writing early. The first significant writing task should be in the first months of your research program.

Right from the start, expect to accumulate useful fragments of text that will later be drawn into the finished thesis.

Expect to create one chapter at a time.

When planning a schedule for completing the thesis, allow time for:

► Multiple revisions of each chapter.

► Supervisor reading time for each chapter.

Supervisors can be the key bottleneck at submission time. Get chapters to your supervisor as early as possible.

Supervision is a (finite) resource provided by the university. Use it fully; use it wisely.

Writing for examination

In a paper, the primary element is the contribution: whether the research is novel, interesting, and correct.

In a thesis, the primary element is the competence: whether the student is capable of undertaking independent research.

Evidence of competence:

- A good research outcome.

- A clear, consistent presentation – poor writing suggests muddled thinking.

- A thorough critical analysis:
  What do the results imply?
  Where did the research succeed?
  Where did it fail?
  What problems were *not* solved?
  What questions are suggested?

Fluid writing

First write down every point that might be worth describing or discussing. Make a conscious effort not to criticise. If it crosses your mind, write it down.

Then critically select: work through the points, organising them by topic, discarding or setting aside things that on reflection don't seem to be valuable.

Write uncritically. Don't get frozen – keep writing, even if you have to delete it later.

(But **do** delete it later.)

Fluid writing . . .

Don't worry about formatting until later on.

Be objective; don't confuse beliefs with facts.

Keep writing; the act of writing tells you what you don't know and helps to focus attention on details.

Revise critically, put your ego aside.

'I used to think about my sentences before writing them down; but . . . I have found that it saves time to scribble . . . whole pages as quickly as I possibly can . . . Sentences thus scribbled down are often better ones than I could have written deliberately.' – Charles Darwin

Making progress

Start writing early.

Set aside blocks of time.

Carry your work with you (mentally and preferably physically).

Set yourself problems, reexamine them between other tasks, keep the concepts active.

Don't expect steady progress but do make progress overall.

Adjust your commitments in response to progress.

Work to realistic deadlines. If other people will need to read a draft, factor in enough time for them to do so.

Don't assume that a version you are happy with is final. *Any* document might have to be drastically revised after feedback.

Keep all constraints in mind: length limits, time limits, audience.

Proofreading and editing

Use a spell-checker – maybe.

Spelling errors aren't everything:

- ▶ Writing 'form' for 'from', 'complete' for 'compute'.
- ▶ Double words, missing words, wrong punctuation.

Put aside for a few days before revising.

Edit harshly:

- ▶ Be critical.
- ▶ Hunt for inconsistencies.
- ▶ Don't count the cost of revisions that improve the text.
- ▶ Read right through, several times.

Editing example

String hashing is a fundamental operation, used in countless applications where fast access to distinct strings is required. Because strings are of variable length and unpredictable or unknown character distribution, standard arithmetic-based approaches are inappropriate or inefficient. Alternative approaches that process strings character by character need to be carefully designed to avoid excessive computational costs. In this paper we describe a class of string hashing functions and explore its performance. These functions use bitwise operations for efficiency and can be randomised through an initial seed. Using experiments with both small sets of keys and a large key set from a text database, we show that it is possible to achieve distribution of keys close to that theoretically predicted for hashing functions. Table sizes do not need to be prime. Even tables whose sizes are powers of 2 have no more collisions than predicted for a random distribution. While other classes of function can achieve similar distribution effectiveness, we show that they are not efficient. We also consider criteria for choosing a hashing function and use these criteria to compare our class of functions to other methods for string hashing. These results show that our class of hashing functions is reliable and efficient, and is therefore an appropriate choice for general-purpose hashing.

A possible revision:

String hashing is a fundamental operation that can be used whenever fast access to distinct strings is required. Approaches that process strings character by character need to be carefully designed to avoid excessive computational costs. In this paper we describe a class of string hashing functions that use bitwise operations for efficiency. Using experiments with small and large sets of keys, we show that it is possible to achieve distribution of keys close to that theoretically predicted for hashing functions. While other classes of function can achieve similar distribution effectiveness, we show that they are not efficient. These results show that our class of hashing functions is reliable and efficient, and is therefore an appropriate choice for general-purpose hashing.

Proofreading and editing . . .

Aim to look professional.

- ▶ Tidy margins.
- ▶ Neatly arranged.
- ▶ Not too dense, not too sparse.

Get someone else to read it . . . and believe your critics.

'If a conscientious reader finds a passage unclear, it has to be rewritten.'
– Karl Popper

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Why write well?

'The final cause of speech is to get an idea as exactly as possible out of one mind and into another.'
– G. M. Young

Consider:

'In respect to the relative costs, the features of memory mean that with regard to most systems today disk has greater associated expense for the elapsed time requirements of tasks involving access to stored data.'

Bad writing is a waste of time.

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Good writing

'Vigorous writing is concise. A sentence should contain no unnecessary words for the same reason that a machine should contain no unnecessary parts.' — William Strunk

'Everything written with vitality expresses that vitality; there are no dull subjects, only dull minds.' — Raymond Chandler

Take the trouble to write well:

- ▶ Lively writing suggests a lively mind.
- ▶ Bad writing suggests confusion.
- ▶ Dull writing is hard reading.
- ▶ No tale is so good that it can't be spoiled in the telling.

'Good writing' is much more than correct grammar and clear expression.

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Good writing …

Is appropriate:
'Whether 'tis nobler in the minde to suffer the slings and arrowes of outragious Fortune …'
versus
'Whether 'tis nobler for the process to suffer the costs of many disk accesses …'

Is transparent:
Form should not distract from content. (Consider a car in which the pedals have been reversed.)

These criteria can be applied to organization, arguments, experiments, notation, nomenclature, choice of words, …

Style

From an Australian company's functional specification for a database system:

'Development of these linkages is likely to be further down the timeline than the implementation of the main system in the near future.

'The system should be developed with the end users clearly in view. The system must therefore run the gamut from simplicity to sophistication, robustness to flexibility, all in the context of the individual user.

'From the first tentative familiarisation steps, the consultation process has been used to refine the requirements by continued scrutiny and rigorous analysis until, by some alchemical process, those needs have been transmuted into specifications. The aim of these specifications is to distill the quintessence of the existing system.'

Style . . .

From an honours report, on implementation of information retrieval:

'Grep is no doubt simple, but inevitably slow, especially if all the documents are to be matched. Further the regular expressions used to specify the string pattern desired can be a hurdle! Worst still when just about everything that might go wrong for the day, and Alas! you are presented with a list of maybe 25 matching documents.'

From a paper:

'Query languages have changed over the years. For the first database systems there were no query languages and records were retrieved with programs. Before then data was kept in filing cabinets and indexes were printed on paper. Records were retrieved by getting them from the cabinets and queries were verbal, which led to many mistakes being made. Such mistakes are impossible with new query languages like QIL.'

Style . . .

The first sentences of some recent information retrieval papers:

'The number of texts in digital form increases rapidly and tremendously.'

'With the continuing growth of online text resources, it is becoming more and more important to help users to access information and to develop easy to use information research tools.'

'Text summarization is an increasingly pressing practical problem due to the explosion of the amount of textual information available.'

'Since the advent of the printing press in the fifteenth century, the amount of printed text has grown to an overwhelming scale.'

'The explosive growth of the world-wide web has dramatically increased the speed and the scale of information dissemination.'

'With the explosion of on-line non-English documents, cross-language information retrieval (CLIR) systems have become increasingly important in recent years.'

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Style . . .

But wait, there's more.

'The rapid increase in the availability of electronic documents has created high demand for automated text analysis technologies such as document clustering, summarization, and indexing.'

'Professionals receive increasing amounts of information, some of which is time sensitive and is important for them to consider.'

'With tons of information pouring in every day, text summaries are becoming essential.'

'The rapidly increasing content in distributed information retrieval (IR) systems for unstructured text has motivated performance improving techniques such as *partial replication with replica selection*.'

'With the exponential growth of information on the internet and intranets, it is becoming increasingly difficult to find and organize relevant materials.'

Style . . .

And even more.

'As information and users proliferate throught the Internet and intranets, distributed information retrieval systems must cope with the challenge of scale.'

'The proliferation of online resources, the growing need to conduct searches across many of these resources, and the de-facto requirement of pruning the resource set of interest to manageable size has increased attention on retrieval in the distributed environment.'

'The research on information retrieval (IR) is boosting with the coming of the Information Age.'

'Undoubtably, the volume of data retrieval systems face is booming up even more quickly than one can think about.'

'An ideal vector space is the base of IR research, so the basic problem of IR is to set up a suitable vector space, in this suitable vector space, query and document can be represented well by vectors."

Style . . .

'If the Lessee shall commit a breach or fails to observe or perform any of the covenants contained or implied in the Lease and on his part to be observed and performed or fails to pay the rent reserved as provided herein (whether expressly demanded or not) or if the Lessee or other person or persons in whom for the time being the term hereby created shall be vested, shall be found guilty of any indictable offence or felony or shall commit any act of bankruptcy or become bankrupt or make any assignment for the benefit of his her or their creditors or enter into an agreement or make any arrangement with his her or their creditors for liquidation of his her or their debts by composition or otherwise or being a company if proceedings shall be taken to wind up the same either voluntarily or compulsorily under any Act or Acts relating to Companies (except for the purposes of reconstruction or amalgamation) then and in any of the said cases the Lessor notwithstanding the waiver by the Lessor of any previous breach or default by the Lessee or the failure of the Lessor to have taken advantage of any previous breach or default at any time thereafter (in addition to its other power) may forthwith re-enter either by himself or by his agent upon the Premises or any part thereof in the name of the whole and the same have again repossess and enjoy as in their first and former estate and for that purpose may break open any inner or outer doorfastening or other obstruction to the Premises and forcibly eject and put out the Lessee or as permitted assigns any transferees and any other persons therefrom and any furniture property and other things found therein respectively without being liable for trespass assault or any other proceedings whatsoever for so doing but with liberty to plead the leave and licence which is hereby granted in bar of any such action or proceedings if any such be brought or otherwise and upon such re-entry this Lease and the said term shall absolutely determine but without prejudice to the right of action of the Lessor in respect of any antecedent breach of any of the Lessee's covenants herein contained provided that such right of re-entry for any breach of any covenant term agreement stipulation or condition herein contained or implied to which Section 146 of the Property Law Act 1958 extends shall not be exercisable unless and until the expiration of fourteen days after the Lessor has served on the Lessee the Notice required by Sub-section(1) of the said Section 146 specifying the particular breach complained of and if the breach is capable of remedy requiring the Lessee to remedy the breach and make reasonable compensation in money to the satisfaction of the Lessor for the breach.'

Style . . .

The volume of information has been rapidly increasing in the past few decades. While computer technology has played a significant role in encouraging the information growth, the latter has also had a great impact on the evolution of computer technology in processing data throughout the years. Historically, many different kinds of databases have been developed to handle information, including the early hierarchical and network models, the relational model, as well as the latest object-oriented and deductive databases. However, no matter how much these databases have improved, they still have their deficiencies. Much information is *in* textual *format*. This unstructured *style of* data, *in contrast to the old structured record format data,* cannot be managed properly by *the* traditional database models. Furthermore, *since so much information is available,* storage and indexing are not the only problems. We need to ensure that relevant information can be obtained upon querying *the database*.

Style . . .

From the 1993 Melbourne University student diary:

'Campus arts will explode straight through the very axis of student activity in 1993.

'Flavour and texture hovering on the brink of hysteria, awaiting only your fleeting smirk, sigh or gasp to descend, and to devastate all tendencies towards ordinariness, indifference and convention.

'Ideas? Hurl them at the Arts Committee, and help to see them through to your wildest expectations.'

Personality?

Much non-technical writing is intended to convey messages about the personality of the author.

Readers make conscious and unconscious judgements about authors on the basis of the personality signals they send (frivolous, silly, judgemental, hasty, careless, ...)

In technical writing strong personality signals should be avoided, such as:

- ▶ Inappropriate judgements or criticisms.
- ▶ Pop culture references.
- ▶ Most clip-art.
- ▶ Unusual choices in layout, design, ...

Style basics

Spell correctly and stay within your vocabulary.

Express yourself clearly and avoid elementary mistakes in grammar and punctuation. (Don't get on the wrong side of the apostrophe police.)

Avoid clichés, slang, truisms, idiom, and stock phrases.

Try out alternative ways of explaining things. Cut out text that isn't necessary.

Answer the right question.

Be accurate and precise.

Top 5 failings

5. Lazy, ugly, and obscure illustrations.

4. Background and literature review crushed into a few paragraphs to make space for unnecessary detail in other sections.

3. Inadequate experiments that don't support the claims.

2. Poorly edited, disjointed introduction, discussion, and conclusions.

1. Lack of a clear, critical argument linking results and conclusions.

Procedural matters

Whatever word processor you use, *make sure* that you know how to use styles.

(Use LaTeX for technical or mathematical writing.)

Use a package for managing citations and cross-references. *Do not* attempt to maintain figure numbers by hand.

Back up your work every day. While you are editing, save every few minutes. Keep backups in multiple locations.

Keep note of your common mistakes in writing, etc., and check your work for them *before* showing it to your supervisor.

Do not use a professional technical writer to edit or author text for your thesis.

Putting it together

Write early and write often.

Let the writing drive the research.

Be clear about your purposes and goals.

Develop a narrative.

Know your audience.

Take care with presentation as well as content.
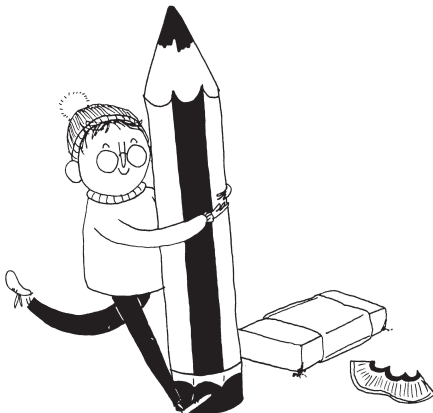
Demonstrate your understanding of the material.

Use your supervisor and colleagues.

Image courtesy Anna Zobel