



An Introduction to Scientific Writing

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Chapter 0

Preamble

This document serves as the getting started guide to research work at the CoDiS Lab Graz. To enable more straightforward navigation and to keep the file concise, this file includes further links with more detailed explanations for specific topics. In case you notice a topic is missing either entirely or just missing details, feel free to contribute.

Some additional advice related to scientific writing at the CoDiS group:

- In general we use LaTeX since it emphasizes on writing and you do not have to waste time with formatting your work. Check out the Overleaf¹ tool, you will find some useful templates (even from our group) that will make your life easier. Another huge benefit is that you do not have to install TeX on your local computer and deal with package dependencies and so on. Overleaf also makes it easy to collaboratively work on documents.
- We use APA style for citations. This document also includes a brief overview on how to properly cite APA.

¹<https://overleaf.com/>

Chapter 1

Introduction

This chapter mainly discusses how to start the research process. First it explains how to decide on a specific topic for a theses or a paper. Once the topic is chosen, a main research question which frames the overall research is defined and further sub-questions which can help guide the process are formed.

1.1 Pick a Research Topic

Countless students begin their research by jumping straight to a solution to a problem before they have given the problem adequate thoughts. To identify a research topic, a student should be prepared to question previously held beliefs (Luse, Mennecke, & Townsend, 2012).

The first step in the research process is to identify a broad research topic representing a broad area, discipline or function. To pick the best research topic for you try to familiarise yourself with as many topics as possible (Horan, 2009). This can be done in numerous ways. Some of the possibilities include:

- Brainstorming - Write down ideas that may not make complete sense while reading or reflecting on research (Luse et al., 2012).
- Enrolling in a diverse set of subjects in order to get a better idea of possible research topics (Horan, 2009).
- Thinking outside the box - Exploring research being done in different areas by looking at the conferences relevant for your research (Luse et al., 2012).
- Finding Partners - Talking to classmates, friends or academic staff about their experiences in different research areas (Luse et al., 2012).
- Read papers that are interesting for you and see if there is a gap in research (often found in the Discussion section, stated as "Future Work") (Horan, 2009; Luse et al., 2012; Saunders, Lewis, & Thornhill, 2009).
- Talking - We often think that we understand the problem, but talking about it forces us to determine our understanding of the problem (Luse et al., 2012).

Once you get an idea of what is out there try to identify what research topics spark your interest, curiosity and where you might have ideas for further improvements and research.

1.1.1 Clarifying the Research Topics

Especially when starting into a new research area it can be demanding to find a particular topic. This is often caused by a missing coherency through this topic and different strings of ideas.

Three methods for approaching a problem that allows the researcher to understand the problem more before attempting to find a solution:

- Isolate and give structure - The researcher should isolate the problem from other outside factors to gain an understanding of the underlying problem itself. To give the problem structure, the researcher has to define concepts within the problem (Kuhn, 1962; Luse et al., 2012).
- Magnify the problem - The next step is for the researcher to elaborate the problem. By elaborating on the theoretical foundation following the problem, the researcher can obtain a better understanding of the problem itself (Kuhn, 1962; Luse et al., 2012).
- Search for theory - The search for theory is a validation step that a researcher should use to validate the problem and ideas behind the problem (Kuhn, 1962; Luse et al., 2012).

The following approaches can help bring a structure into the process of picking a research topic.

- Mind map: Mind maps are a quite common approach for structuring information. The starting point of a mind map (and the central node) is a key term which symbolises the essence of the researched topic. A mind map is basically a network of concepts that are related together (connected using lines or arrows). It is recommended to perform a literature survey in order to not miss key features that should also be covered and later integrate them into your mind map. A mind map provides an overall picture of the topic and related concepts.

Creating a mind map can be done in various ways, a traditional paper and pen approach and also using technology (e. g. Mindmeister¹, or Coggle²)

- Continuous Writing and Refining: As you read more about your topic you will discover new areas which might be interesting to mention in your document. To avoid having to reread large parts of already read literature you should try to write as soon as you read an interesting part of literature. Additionally you might wish to refine some aspects of your work as you read more content and get exposed to more new ideas.

1.2 Define Research Questions

Once you found a topic worth working on, the next step is to define an appropriate research question. It is important to think of research questions beforehand since they have a tremendous impact on the methods and approaches used in the research. All activities conducted in research (e.g. studies, evaluations, implementations, surveys, etc.) should help answer the research question. Start by asking yourself what you would like to find out and write down each of the questions that fall into your mind. Once you have a set of questions, try to organise them in a hierarchy where you have a primary research question followed by up to three sub-questions.

When defining research questions, it is important to formulate them in an open-way, not answerable with “yes” or “no”. For example “How do the newly implemented UI changes affect the usability of tool X?” instead of “Do the newly implemented UI changes improve the usability of X”. By doing so you enable yourself to report on the finer details of the evaluation.

An alternative approach is to set a hypothesis and try to either prove it or disprove it. To formulate even better questions, ask your supervisor or fellow students for their feedback and try to iterate based on that.

Some other examples of good research questions:

¹<http://www.mindmeister.com/>

²<https://coggle.it>

- *Does an introductory MOOC on coding increase the quality of programming skills through a university programming course?*
- *How do the new UI changes and new features affect students experience while using our tool?*
- *Which emotions do users experience when using a dialog system?*

Chapter 2

Literature Survey

The goal of this chapter is to familiarise yourself with the main concepts of a literature survey. After reading this chapter, you should be able to extract keywords from your research questions and research area and use a combination of tools to find literature (e.g. papers, books, online articles, etc) related to your research questions and also process it in an appropriate manner.

2.1 Popular Literature Sources

The best way to start your search for relevant papers is to use one of many popular research focused search engines and repositories. These usually offer a wide selection of published papers. Once you find papers you might be interested in try to pay close attention to a set of different aspects:

- Publication year - which will give you a good idea of how recent a certain paper is and how relevant it is for the current time and environment
- Citation number - papers with high citation count may have a bigger impact in the field and may provide you with useful context for your research. However, citations do not mean a paper is absolutely good.
- The conference or journal ranking - which enables you to further narrow down which papers are impactful and should be read. Papers published in high ranking conferences and journals tend to be more meaningful for a research area.

Once you find some interesting papers a good approach of discovering more papers which might be relevant to your research is to pay close attention to the authors and conferences or journals of the selected papers. By looking at the authors profiles on different research repositories (such as google scholar) and by investigating the conference proceedings or previous journal issues of the conference or journal where a paper has been published you may stumble upon other work with the same focus.

Some of the various paper repositories can be seen in the following list:

- [Google Scholar](http://scholar.google.com)¹
- [SpringerLink](https://link.springer.com)²
- [IEEE Xplore](https://ieeexplore.ieee.org)³
- [ACM Digital Library](https://dl.acm.org)⁴

¹<http://scholar.google.com>

²<https://link.springer.com>

³<https://ieeexplore.ieee.org>

⁴<https://dl.acm.org>

- CiteSeerX⁵
- arXiv⁶
- ResearchGate⁷

Some of these sites also learn your interests over time and provide you with useful suggestions for new interesting papers via their newsletter. Finally when searching for papers it can be very beneficial to find survey papers which provide the reader with an overview of the field (Keshav, 2007). Usually these are an excellent starting point when exploring a new topic.

2.2 Keyword Research

Based on your research question and your research topic try to identify keywords which might be relevant for your field. For example if the field is information retrieval try with something as simple as writing information retrieval into one of the aforementioned repositories to get an idea of popular papers and authors. Next, try keywords which are more specific to your research questions. For example if your research question is "How does X impact keyphrase extraction" try searching for "keyphrase extraction". Finally, once you have identified interesting papers you can also pay close attention to the keywords section of the selected papers since they might contain further interesting keywords for your research. An additional approach for discovering new and relevant keywords is using a tool like Google Trends⁸ and exploring the latest search trends. This can be a good indicator of what is happening in your research field.

2.3 Reference Manager

Once you find interesting papers it is recommended to store and organise them in a meaningful way for later reading and use. The most popular way of doing that is using a reference manager such as Mendeley⁹ or Zotero¹⁰. These provide you with useful functionalities such as sorting papers in folders, adding notes to papers, adding keywords and more. Furthermore they sync on multiple devices and enable you to have your collection of papers always in reach.

2.4 How to Read a Paper

Scientific papers usually follow a specific structure (See also [chapter 3](#)):

- *Abstract*: An abstract contains all necessary information of a paper in brief form. This covers the general topic, central questions related with it, the addressed problem, related/previous research, the goal of the research, methods and approaches, the main findings/results and the implications of these.
- *Introduction*: The goal of the introduction is to make the readers aware of the context of the paper and explains why it is important. It gives an overview of the research questions and the significance in research. Introductions often also includes an overview of the paper's structure.

⁵<https://citeseerx.ist.psu.edu>

⁶<https://arxiv.org>

⁷<https://www.researchgate.net/>

⁸<https://trends.google.com/trends/>

⁹<https://www.mendeley.com>

¹⁰<https://www.zotero.org>

- *Literature Review*: This chapter gives an overview of related work and similar approaches to clarify where to locate the research covered in the paper. This chapter also shows gaps in research that will be closed in the paper.
- *Methods*: The design of the research/study is explained including all techniques and approaches that were used in order to collect all information within the scope of the research question.
- *Results*: Within this chapter all findings are summarized.
- *Discussion/Conclusion*: This chapter is rather important since all aspects are summarized. The findings are brought into context with the research questions and related literature to clarify how the conducted research lead to a better understanding within the scientific field.

An example of a method for approaching paper reading is the three pass method which will be described in the following paragraphs (Keshav, 2007). When you stumble on a paper, you should first skim through the title, abstract, introduction and conclusion. Furthermore, you should also look through the section and subsection titles, the mathematical content and the references. At this point you should know what is the type (category) of the paper, how it relates to other papers (context), do the results seem to be valid and correct (correctness), what is the main contribution and if it is clearly written. Based on this newly gained information, you can decide if the paper is relevant for your research and if you want to read it in more detail.

Next, we want to focus on the paper details and reread the paper, but this time by covering the entire paper except for details like proofs. It is useful also to write some notes about the critical aspects of the paper and even open questions or new terms. While reading, you should also pay attention to details to properly assess if the paper was written with care and attention to detail to separate high-quality work from the rest. At this point, you should be able to sum up, the paper and it's critical findings and assess what to do next. In case the paper is not the main focus of your research, and it's not necessary to understand it in detail you may decide to put it aside in your reference manager and continue reading another paper. However, if you would like to develop a deeper understanding of the paper, you should go through it again.

In the third pass, you should put yourself in the shoes of the author and try to understand how the author came to every part of the paper. This should take a longer time, and by the end, you should have a deep understanding of the paper, it's strengths and weaknesses.

It is advised to have some time between reading the paper the first, second and third time (Keshav, 2007). Furthermore, it's usually a good idea to write the literature overview part of your research work as you read the relevant papers in order to avoid issues such as forgetting what you read and what your notes meant to cover.

Some helpful tips when reading papers:

- Try to finish a paper in the same day as you start it in order to avoid re-reading.
- If you find it hard to concentrate try the Pomodoro technique or simple time measuring in order to have a better sense of how much work you invested.
- Always try to keep in mind your research question(s) and how the paper you are reading fits into and helps you with your research.

2.5 Conference and Journal Ranking

In academia there are two main formats how papers are published: conference and journals:

- A conference paper is usually published after the research is presented at the conference. The collection of all papers which were written as part of the conference will be published in the so called *proceedings*. The advantage of conference papers is a shorter feedback cycle compared to journal papers, since all submissions have to be available to a given deadline.

- As the name suggests journal papers are published in journals. Reputable journals usually follow a peer-reviewing process, where each submission will be reviewed by researchers of the same field. In this way the quality of journal publications can increase since sometimes more feedback cycles exist. Another benefit of journal papers is the higher impact factor compared to a conference publication.

For each journal and conference the impact and significance is different and can be measured by different metrics like the number of citations, or the number of accepted publications. To get an overview of the quality of a journal or conference several websites can be considered:

- SJR Journal Ranking¹¹
- Conference Ranks¹²

¹¹<https://www.scimagojr.com/journalrank.php>

¹²<http://www.conferenceranks.com/>

Chapter 3

Scientific Writing

This chapter will give an overview of scientific writing, including best practise for successful writing, the structure of a theses and some advise how to plan a theses.

3.1 Guideline to Successful Writing

When writing your research work it is important to follow some general guidelines. The majority of the following guidelines were taken from ([Andrews, 2019](#)).

- **Research solution name:** If the solution you developed as part of your research work has a name refer to it by its name instead of writing "the tool", "the solution" or anything similar.
- **Chapter structure:** Every chapter of your thesis should start with an introductory paragraph and end with a summary paragraph where you described what was presented in the chapter.
- **Word contractions:** Avoid using word contractions. Instead of using "can't", "won't", "I'm", "It's", use "cannot", "will not", "I am" and "It is".
- **Single children:** Avoid having chapters with one section, one sub section or similar.
- **Passive:** It is generally suggested to use passive form (for example "The analysis was performed ...") instead of active (for example "We performed the analysis ...") unless there is a very good reason for using active form.
- **Avoid gender bias:** Use gender neutral terms when writing your text.
- **Present and past:** Try to consistently use the same time. Either use present or past but avoid mixing as much as possible.
- **Quoting:** In case you are quoting some work (using the exact word by word structure) it should be in italic with appropriate citation at the end.
- **Abbreviations:** If possible introduce abbreviations for phrases which are appearing often by introducing them in parentheses with the first use of the phrase. For example "Information retrieval (IR) is a field ..." and later "as part of our IR process we ...".
- **Images:** When presenting figures from other research work either write "Taken from (citation)" or "Redrawn after (citation)" in the figure caption.
- **Captions:** The figure captions should be positioned at the bottom of a figure while table captions should be on the top of a table. Furthermore, make sure to refer to the figure or table also in your text (for example "The detailed analysis results seen in Table 3 indicate ...").

3.2 Structure of Theses

The following section gives an overview of a possible structure of a theses. This skeleton can be modified in order to the certain needs of the theses. When developing a new tool for example a pre-study is often not necessary, since the requirements are the result of an extended literature survey.

1. Introduction
What's the aim of my thesis? What methodology do I use? What are the main contributions to research? How is the work structured? What's the research questions?
2. Background and Related Work
Theoretical background of the work; Where is a gap in research? What are similar approaches? How do they differ?
3. (Pre-study)
If you did a pre-study/evaluation on a certain topic state the results. What did you evaluate? Where are the problems? How could they be solved?
General: This is optional and depends on your previous research. This can also be part of the background section.
4. Requirements and Concept
Analysing the requirements based on gaps in research or pre-study. What functional and non-functional requirements are given? What's the concept? Conceptual Architecture is always great here.
5. Development/Implementation
Details on the implementation. Give some technical insights to the system. Use diagrams, UML, code snippets, screenshots, etc. Everything that helps to understand your work helps in this chapter.
6. Evaluation
 - Scope: What was the scope of this evaluation? What were the main questions?
 - Instruments and Setup: What questionnaires, data, etc. did you use? How was the setup of the experiment/intervention?
 - Participants: Describe who participated in the experiment. Why this population?
 - Results: Describe your results in a qualitative/quantitative way. Use the right diagram type
 - Discussion and Limitations: Summarize your experiment. Be aware that there are limitations in the evaluation. Limitations are a great point for future work!
7. Lessons Learned
What are the lessons learned in terms of research, development and your topic? What is new?
8. Conclusion and Future Work
Summarize your work and conclude it. What were your main contributions? What did you do? Where do you see possible improvements for future work?

3.3 Thesis Planning

When planning your thesis writing try to keep in mind that in addition to writing your thesis you will spend a large part of your time on reading related literature, developing your solution and evaluating your solution. In order to avoid writing the thesis at the end when all work has been done and when you might have forgotten some important details of the related work it is advised to write the background

and related work chapter first. In addition this will bring context and structure to the rest of your thesis since you will have to outline how it connects to prior work. Next you want to focus on the introduction to your research and on what you have done as part of your research work. You then present the results of your research work in detail. Finally you write the conclusion, introduction and abstract in order for them to fit in with the rest of your work.

Chapter 4

Citation

Citations are used to state that certain thoughts and ideas are taken from another person. In this way you can let your readers distinguish between your contribution and work from others. This includes a quote, a paraphrased text, a table, a figure, etc. Proper citing and referencing prevents from plagiarism and is therefore a vital element of serious research projects.

There is a number of different citation styles: APA, Turabian, Chicago, etc. The style differs depending on the field of research and the scientific community. In general there are two types of citation systems: author-year style and numeric style.

This chapter covers two important aspects of scientific writing: citations and references.

- *Citation*: A citation is an in-text identification that indicates a phrase, sentence, idea, figure, or table as work of a different person.
- *Reference*: The reference list includes all sources that were used within the work. It is added at the end of a project.

The *American Psychological Association* style guide is commonly used in different fields and publication formats. The following sections will give an overview of the APA fundamentals, further information can be found at the official website of APA style guide¹.

4.1 In-text Citations

An APA in-text citation consists of two key elements: i) last name of author(s), and ii) year of publication. An additional element can be the page number² When using an author-based citation system two types of citations are common: *parenthetical* and *narrative*.

- *Parenthetical Citation*: A parenthetical citation can appear within or at the end of a sentence. It includes i) author name(s) and ii) publication year within the parentheses.

The usage of game-based learning within a beginner course can led to a significant improvement of the digital skills (Baur & Mya, 2016).

- *Narrative Citation*: The last name of the author(s) is already used within the text. The publication year is placed straight after the name(s).

¹<https://apastyle.apa.org/>

²The page number is especially used when citing a book.

Author Type	Parenthetical Citation	Narrative Citation
One Author	(Selvig, 2008)	Selvig (2008)
Two Authors	(Stark & Banner, 2012)	Stark & Banner (2012)
Three of more authors	(Cooper et al., 2019)	Cooper et al. (2019)
Group Author	(Graz University, 2020)	Graz University (2020)

Table 4.1: Comparing parenthetical and narrative citation style.

Baur & Mya (2016) investigated the impact of game-based learning in a beginner coding course.

Quotes can be either word-by-word (*direct quote*) or a paraphrased form of a text (*indirect quote*). Direct quotes have to be exactly the same as in the source text (even capitalization³). When citing publications with one or two authors, the last name(s) are written within parentheses. Publications that include three or more authors just cite the first author and followed by the abbreviation *et al.*⁴ Table 4.1 gives an overview of both the parenthetical and the narrative citation.

Additional Information:

- In-text citations never include first names, degrees (Dr., MSc, etc.), official titles (Prof.), or name affixes (Jr., Sr., etc).
- Multiple works can be placed in the same parentheses: (*Ming, 2016; Braun & Blau, 2019*).
- Publications from authors with the same names in the same year are cited with a lower-case letter after the year: (*Ming, 2018a; Ming 2018b*).

4.2 Reference List

The reference list appears at the end of the document including all publications that are cited within the text. The reference list should be complete and consistent. An entry in the list consists of at least four elements:

- Author(s)
- Date
- Title
- Source

All elements are separated using a period (except URL or DOI⁵, since it could break the link). Elements of the same type (such as author names) are separated using punctuation marks.

Berges, M., & Hubwieser, P. (2015). Evaluation of source code with item response theory. In Proceedings of the 2015 ACM Conference on Innovation and Technology in Computer Science Education (pp. 51-56). <https://doi.org/10.1145/2729094.2742619>

³When a direct quote requires some slight modification in support of a correct spelling/grammar slight changes are possible. These modifications have to be indicated modification using square brackets: *Paul et al. (2017) show that "[d]igital skills will lead to a better understanding [of sequencing]."*

⁴et al. is derived from the Latin 'et alii' which means 'and others'.

⁵DOI means *Digital Object Identifier* which is a unique identifier for a digital object (similar to ISBN or ISSN numbers).

The reference list will be placed on a separate page at the end of the document and contain all in-text references. The list should be ordered alphabetical by the authors last name.

4.3 Citations/References in L^AT_EX

The major advantage when using L^AT_EX is, that many aspects related to citations and references will be done automatically. To enable APA citations within a L^AT_EX document the package *apacite* has to be included (see Listing 4.1). This package can also be used as bibliography style (in order to keep the reference list in APA style).

Listing 4.1: Skeleton of a LaTeX document using APA citation.

```
\documentclass{report}
\usepackage{apacite}

% Some elements in-between ...

\bibliographystyle{apacite}
\bibliography{bibliography.bib}
```

The package provides different possibilities for in-text citations. The two most important style types (parenthetical and narrative) can be created using the following commands:

- `\cite{Kuhn1962}`: (Kuhn, 1962)
- `\citeA{Kuhn1962}`: Kuhn (1962)

Another key advantage of using L^AT_EX is the possibility to create a reference list automatically. This feature is a double-edged sword, because it also gives a false sense of security, since information can be missing or inconsistent. Many scientific databases and libraries are offering citation export in various formats. The BibTeX format can be used to get all relevant information about a publication. This entry can be pasted into the bibliography (separate file). BibTeX supports different publication types such as proceedings, books, articles, theses, etc. According to the specific publication type different data fields (edition, conference, institution, etc.) can be required. Listing 4.2 shows a sample BibTeX text format for a book. To create an in-text citation the following command is necessary `\cite{Martin2009}`.

Listing 4.2: BibTeX entry of a sample book

```
@book{Martin2009 ,
  author = {Martin , Robert C. and Coplien , James O.} ,
  title = {Clean Code: A Handbook of Agile Software Craftsmanship} ,
  publisher = {Prentice Hall} ,
  year = 2009
}
```

Chapter 5

Designing a Study

User studies are an important part of your research since you will present your project to users and they will try it. Designing user studies has to be well considered because if you will make a wrong decision this can influence your whole experiment. On the other hand, if you put enough thought and consideration into your user study it will help you structure your work and also understand it better. So do not underestimate the importance of a well-designed user study.

1. Formulate questions beforehand!

The first step is always to define a research question. Formulate them in an open-way, not answerable with “yes” or “no”. For example “How do the newly implemented UI changes affect the usability of tool X?” instead of “Do the newly implemented UI changes improve the usability of X”. By doing so you enable yourself to report on the finer details of the evaluation instead of just answering the question with “Yes” or “No”. An alternative approach is to set a hypothesis and try to either prove it or disprove it. In order to formulate even better questions ask your supervisor or fellow students for their feedback.

2. Plan your study

As soon as you have defined your research question, plan what you might want to ask. Ask yourself the following questions

- What is the focus of the study?
- What should the study look like?

Different fields have different instruments you could use for your study, check the current state-of-the-art. It is a good approach to think in detail of all aspects of your research questions (What questions do you want to ask? What tasks should be done? What data you need to collect?). In case you are collecting data from multiple channels (e.g. survey and interaction tracking) and would like to connect the different data sources, think in advance how you could do that.

Especially when you do your first studies, make a time plan, this will really help you.

Hint: An ethics approval can appear as lots of work (and it is!) but it will help you so much to re-think every aspect of your research.

3. Run a pilot test

A pilot test will reveal many things! You will see if the study design is appropriate for the group, it shows you if the tasks are good and also if your evaluation instruments are well-considered. Try to run the pilot test under similar conditions than the upcoming experiments.

Hint: Prepare yourself a sheet of paper and a pencil to make notes during the experiment. You might want to use a template like this one.

4. **Define focus groups**

After the pilot test (and maybe some minor adaptations) you are ready for the evaluation. Therefore, you should define groups according to your study design. If you want to compare something for example (old version vs. new version) A/B tests are suggested. If you want to introduce a new software and run a usability evaluation you should consider different focuses (such as each group gets a certain module to evaluate).

5. **Run Evaluation**

Now you can run the actual evaluation with your defined groups. Always consider that you want to answer certain research questions with your evaluation.

Hint: Same as in pilot test, make notes, write down improvements.

6. **Let participants answer survey/questionnaire**

A survey is a vital part of your work since it contains information that you need for your evaluation. Reconsider each question, does it really help you answer your research question? Answering questionnaires is not the most engaging thing of your study, so maybe you find a way to make it more fun (gamification, awards, etc.)? Do not try to put everything in a questionnaire, it's better to run a second evaluation with a different focus.

Hint: Use an online tool that helps you with data analysis (for example Qualtrics), this will save you lots of time!

Tips:

- Don't overuse open-ended questions since they can be problematic.
- Keep surveys simple!
- How to formulate a research question: [Choosing a Topic: Research Questions](#)

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