

How to write a research/scientific paper?

Overview

Let us begin with what is a research paper and how is it different from an essay?

A research paper aims to convey the author's interpretation, evaluation, or argument, for instance, a review of a piece of scientific literature or an analysis of a new finding. Essays are relatively shorter wherein the subject in question is often broad and is instructed by someone else on what to do. A research paper is more complex and requires an in-depth study on the issue and presentation of other scientists' opinions as well as the writer's conclusion. It is basically a comprehensive written treatment of a subject. It should illustrate that the writer understands the key concepts, and different points of view in it – but also advances a point of view resulting from *original* research.

Remember that 'original' does not mean 'something that's never been done before'. It mostly means: doing something that you do for yourself to address the question being raised out of your curiosity and making a contribution to the research community. For instance, you want to understand how well different countries are doing with vaccination against Covid-19?. This topic has been studied by many scholars, and a lot of data has been collected. Even if that is the case, you can still research on this topic -- if you are truly interested in it -- you still can do something original for this topic. You can look into and model the existing data, and have a new interpretation and insight. You can also look into the previous studies, and see if something is missing there. You can examine those research, see whether they are consistent with one another, and recommend a new methodology. When other researchers read your paper, they can gain some useful information or even build something new based on your work.

Structure of a research paper

A scientific/research paper should include the following sections, and we will talk about each section in greater detail later:

- Abstract
- Introduction
- Materials and Methods
- Results
- Discussion
- Conclusion
- Acknowledgements
- Reference lists

Here is some useful link on the structure of a research paper, click on the following link:

- *Writing a research article: advice to beginners*
<https://academic.oup.com/intqhc/article/16/3/191/1814554>

Abstract

All scientific/research papers begin with a structured abstract (between 250-300 words). An abstract is basically a summary of your paper whose purpose is to convey the readers: a complete, yet concise understanding of your paper's research and findings. It can either be summarised in a single paragraph highlighting the issue being considered, describing how the study was performed to address the question, and concluding the significance of the findings. It can also be structured into following sections :

- Background – summarising the problem being considered
- Methods – describing how the study was performed
- Results – listing the salient findings
- Conclusion – stating the principal conclusion.

Abstract (Good/bad)	Example	Why is it good/bad?
Good Abstract	<p>The cell phone is ever-present on college campuses and is frequently used in settings where learning occurs. This study assessed the relationship between cell phone use and actual college grade point average (GPA) after controlling for known predictors. As such, 536 undergraduate students from 82 self-reported majors at a large, public university were sampled. A hierarchical regression ($R^2 = .449$) demonstrated that cell phone use was significantly ($p < .001$) and negatively ($\beta = -.164$) related to actual college GPA after controlling for demographic variables, self-efficacy for self-regulated learning, self-efficacy for academic achievement, and actual high school GPA, which were all significant predictors ($p < .05$). Thus, after controlling for other established predictors, increased cell phone use was associated with decreased academic performance. Although more research is needed to identify the underlying mechanisms, findings suggest a need to sensitize students and educators about the potential academic risks associated with high-frequency cell phone use.</p>	<p>This is a good abstract because it addresses the background, the purpose of the research, illustrates the methods and reports the findings and also discusses the significance of the results with a coherent concluding statement.</p>
Bad Abstract	<p>This paper presents and assesses a framework for an engineering capstone design program. We explain how student preparation, project selection, and instructor mentorship are the three key elements that must be addressed before the capstone experience is ready for the students. Next, we describe a way to administer and</p>	<p>This poorly written abstract describes only the organization of the paper. Neither does it report the actual findings or</p>

	execute the capstone design experience including design workshops and lead engineers. We describe the importance in assessing the capstone design experience and report recent assessment results of our framework. We comment specifically on what students thought were the most important aspects of their experience in engineering capstone design and provide quantitative insight into what parts of the framework are most important.	results obtained from this study. A good abstract should briefly address the background, methods, results and the final conclusion of the paper
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Introduction

The main content of a research paper starts with a formal introduction which accounts for up to 30% of the overall word count. This section should:

- start with a detailed background reviewing scientific literature about the chosen subject (Literature review is hard! We will talk more about it later.)
- describe the gap in knowledge that your aim and objectives will address
- conclude with a concise statement of your research's Aims and Objectives.

(At this point, your point also considers stating the NULL and ALTERNATE hypotheses)

Hypotheses	Definitions	Examples
Null hypothesis	A null hypothesis states there is no difference between the characteristics of the issue being raised.	If the question is “does chewing willow bark relieve pain?”, then the null hypothesis is: There is no difference in pain relief after chewing willow bark versus taking a placebo.
Alternative hypothesis	An alternate hypothesis states there is a statistically significant difference between the characteristics of the issue being raised.	If the question is “does chewing willow bark relieve pain?”, the alternate hypothesis is that there is a significant

		difference in pain relief after chewing willow bark versus taking a placebo.
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Here we will talk a little bit about literature review. First question is: what is literature review? A literature review is an overview of the previously published works on a specific topic. Here are a few tips about how to do it:

- Narrow your topic and select papers accordingly - don't review every article in the field since you are not writing an 80,000 words dissertation. Talk to your mentor(s). They will help you to navigate the literature.
- Search for scientific literature on google scholar
- Read the selected articles thoroughly and evaluate them
- Organise the selected papers by looking for patterns and by developing subtopics
- Develop a purpose statement.

Here are some useful links on how to write a good literature review:

- *Structure of a literature review:*
<https://www.rlf.org.uk/resources/the-structure-of-a-literature-review/>
- *Beginners guidelines on how to write a good literature review:*
<https://www.nature.com/articles/d41586-020-03422-x>

Materials and Methods

The Materials and Methods section in a research paper enables the reader to grasp a comprehensive understanding of what was done to address the research question and how it was done. It should:

- Describe the context and setting of the study
- Specify the study design and justify the experimental design
- Describe the intervention (if applicable)
- Describe data collection instruments and procedures
- Outline analysis methods

NOTE: Intervention refers to the outcomes of the experimental effects applied on the subjects to conduct the research.

If your project is a lab-based study, you should also describe the materials used and their origin. If you had practical assistance in the collection of the data (samples provided by the supervisor) then this must be clearly stated along with the role you played in generating the data specified.

If your project is computational and the data is obtained from an open database, you need to mention

- the version of the database
- the release date of the dataset you are using
- Measures taken to avoid experimenter bias (filters applied, etc.)

Result

The results should be a detailed description of the findings obtained in the study explained in a logical order. In the results section, you should:

- Report on data collection and recruitment
- Present key findings with respect to the central research question
- Present incidental or secondary findings

Results obtained apart from the primary purpose of the experimental setup are referred to as incidental or secondary findings, as these might be of interest to the reader.

You need to find a good way to present your result, so the reviewers would find it convincing. The question is: *What is a good way to present my data and findings?*

The answer is: keep it simple, first general, then specific. Data should answer the research questions identified earlier in your introduction. The results section should be a detailed report of data and findings and leave the process of data collection solely to the methods section. Always use past tense in describing results.

It is more convenient to use Text, tables, or graphics to present data. Tables and figures should be included where appropriate, with explanatory legends, and appear chronologically as close as

possible to where they are cited. If you need to include any data/results that you did not generate, you must specify that they weren't produced by you and ensure that they are attributed to someone else.

Discussion

The Discussion section should be the summary of what the results show along with an explanation of their meaning. The results section is to provide a detailed description of the findings of the experiment while the purpose of the discussion section is to analyse the data and findings and also correlate with previous experimental studies and illustrate the limitations as well as further prospective research. It should:

- State the main findings of the study
- Discuss the main results with reference to previous research
- Discuss policy and practice implications of the results
- Analyse the strengths and limitations of the study
- Offer perspectives for future work

Conclusion

The purpose of the conclusion is to wrap up your ideas and leave the reader with a final inference of the subject. The conclusion should be a solid paragraph highlighting the purpose of the research, the significance of the results and further scope of results.

Conclusion (Good/bad)	Example	Why is it good/bad?
Good Conclusion	Recent research on cold-water immersion incidents has provided a more complete understanding of the physiological processes occurring during drowning and near-drowning accidents. Current findings suggest that the cooperative effect of the mammalian diving reflex and	This is an example of a good conclusion because, firstly it begins with an overview of previous research

	<p>hypothermia plays a critical role in patient survival during a cold-water immersion incident. However, the relationship between the two processes is still unclear. Because it is impossible to provide an exact reproduction of a particular drowning incident within the laboratory, research is hampered by the lack of complete details surrounding drowning incidents. Consequently, it is difficult for comparisons to be drawn between published case studies.</p> <p>More complete and accurate documentation of cold-water immersion incidents—including time of submersion; time of recovery; and a profile of the victim including age, sex, physical condition—will facilitate easier comparison of individual situations and lead to a more complete knowledge of the processes affecting long-term survival rates for drowning victims. Once we have a clearer understanding of the relationship between hypothermia and the mammalian diving reflex, and of the effect of such factors as the age of the victim, physicians and rescue personnel can take steps to improve patient care both at the scene and in the hospital.</p>	<p>outcomes and then addresses the need to conduct this study followed by reporting the consequences of the findings of this study and also highlights the significance of further research by pushing forth some ideas.</p>
Bad Conclusion	<p>Pollution can kill fish and people. Drinking water becomes unsanitary and unsafe with pollution. If we do not fix the state of our freshwater systems, our health can suffer.</p> <p>Researchers are still trying to help, but they have not resolved the issue of water pollution. As citizens, it is our responsibility to help keep our waters clean and avoid polluting rivers, lakes and oceans</p>	<p>In this example, some elements are missing and the thesis statement is not clear. This conclusion is disorganized and ineffective .</p>

Bibliography

At the end of your writing you must always give a full list of all references that appear earlier in the report in the form of a bibliography.

A reference or citation is a way of properly acknowledging where you made use of the work of others and the proper presentation of citations and references is an important part of any piece of academic writing. You should always use a recognised referencing system. This will determine how you present references in the main body of your work. The best system to use is likely to depend on the type of project you are doing and the conventions of the field you are working in.

Here is a detailed description of in text citations and full reference lists:

<https://www.open.ac.uk/library/help-and-support/quick-guide-to-harvard-referencing-cite-them-right>

- The Harvard system is commonly used in the biological sciences and tends to be a good system to use for more discursive work.

Here is how to cite different sources with Harvard referencing

<https://student.unsw.edu.au/citing-different-sources>

- The Vancouver system is often used in medical journals and may aid clarity and readability where the same item is cited many times.

Here is a quick guide to reference using Vancouver style

<https://www.scribbr.co.uk/referencing/vancouver-style/>

The IEEE style is a numeric style, where citations are numbered in the order of appearance. This citation leads your reader to a full reference to the source in the list of references at the end of your work. Once a source has been cited, the same number is reused for all subsequent citations to the same source.

Here is a guideline on how to reference using the IEEE style:

<https://libraryguides.vu.edu.au/ieeereferencing/journals>

Here is detailed description of how research papers for nature are formatted and referenced:

<https://www.nature.com/nature/for-authors/formatting-guide>

Either referencing style is acceptable but should be consistent throughout. The use of a citation management tool such as EndNote or Mendeley is strongly recommended to help you organize your research, collaborate with others online, and discover the latest research.

Link to Mendeley: https://www.mendeley.com/?interaction_required=true

Link to EndNote: <https://endnote.com>

(NOTE: Further, supplementary information may be supplied as **appendices** to your main findings, this is perhaps felt to provide helpful further context or details.)

Acknowledgements

The acknowledgements section should include a formal acknowledgement of academic support that describes the amount of interaction you have had with your supervisor or other experts in developing your thesis. Additional acknowledgement of other support to recognise other assistance you have received, including practical, administrative and personal matters. In order to be transparent, please clearly describe the work you actually did during your research time; who else was involved and in what aspects of the research, and what work is attributable to them for this thesis; and how long you were working on the project. You should also acknowledge any grant or funding received to carry out your research.

Using LaTeX to write your paper

LaTeX is a high-quality typesetting system; it includes features designed for the production of technical and scientific documentation. LaTeX is the de facto standard for the communication and publication of scientific documents. It is available as free software. You can either download it, or use an online editor.

It is very convenient to use LaTeX instead of a common word processor to structure your piece of writing. LaTeX makes tasks that are difficult and awkward in word processors far simpler.

Here are some useful link on LaTeX:

An introduction to LaTeX

<https://www.latex-project.org/about/>

How to Write a Thesis in LaTeX

[https://www.overleaf.com/learn/latex/How to Write a Thesis in LaTeX \(Part 1\): Basic Structure](https://www.overleaf.com/learn/latex/How_to_Write_a_Thesis_in_LaTeX_(Part_1):_Basic_Structure)