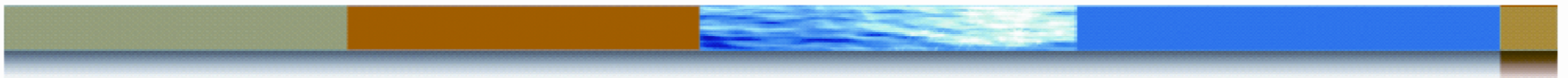# How to do research and write a research paper

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What is Research?

- **Research is to**
  - **Discover new knowledge**
  - **Seek answers to questions**
- **Basic research**
  - **Often driven by curiosity for fundamental/general knowledge/understanding**
  - **High impact examples: relativity theory, …**
- **Applied research**
  - **Driven by practical needs**
  - **High impact examples: computers, transistors, …**
- **The boundary is vague, and distinction isn't important, but all require innovations and discovery of new knowledge; others must be able to learn something new from your work that they can't learn from any existing literature**

What is research?

- Identify a problem
- Find out what others have done
- Develop a solution
- Show your solution:
  - Works
  - Better
  - Sound & complete

Research Process

- Identification of a topic & raise a research question
  - research question = question with no answer, or no good answer described in any literature
- Hypothesis formulation
  - offer a (possible) answer to the research question
  - formulate a hypothesis based on your answer (e.g., "your new method better than an existing method")
- Design experiments to test hypothesis (e.g., compare X and Y on the data)
- Draw conclusions and <u>repeat</u> the cycle if needed

Research paper definition

- A research paper demands the author invest time and thought in analyzing outside sources in order to forge his or her own unique vision of the text or to shed new light on past interpretations. A research paper does NOT consist of the writer merely **rewording** or the thoughts of other authors, but rather must include the writer's own thoughts and reflections on different perspectives. The goal of the writer is to ENGAGE sources and not to simply RESTATE other interpretations. Therefore, it is neither necessary nor beneficial to only include perspectives which are in agreement with your own.

- Your making a new interpretation and providing more insight on the text.

- The author's thoughtful inquiry into the research question should ultimately conclude with the creation of the author's own, unique perspective on the topic. The author does not need to refute or stand in opposition to other readings, but rather shed light on other interpretations or offer a new means by which to understand the topic under inquiry.

- The author will typically develop his or her paper statement throughout the course of researching and writing the paper. It is to the writer's benefit to enter the research paper writing process without a predetermined standpoint and to remain open to the possibility of changing his or her interpretation and go several times throughout the process.

https://www.google.ca/#q=A+research+paper+demands+the+author+invest+time+and+thought+in+analyzing+outside+

Research Paper definition

- A substantial piece of academic writing, usually done as a requirement for a class, in which the author does independent research into a topic and writes a description of the findings of that research.
- A formal written report that includes research findings and a student's own ideas.
- Research papers are all about organizing your ideas in a linear, understandable format.
- A research paper is a report summarizing the answers to the research questions you generated from the sources you gathered information from. Then presenting the work in research paper format.

Choosing an Area of Research

- Before narrowing your focus to a specific claim or interpretation, conduct research in order to gain an understanding of what other individuals have said about the topic. Most students find it useful to examine a wide range of sources before deciding on a specific area of focus.

  - Choose a topic which interests and challenges you. Your attitude towards the topic may well determine the amount of effort and interest you put into your research.

  - Obtain teacher approval for your topic before embarking on full-scale research.

- Select a topic you feel equipped to handle. Avoid topics that are:

(1) too general- try to be specific about what you seek to investigate,

(2) too specialized- in choosing an overly specialized topic you may find you are not qualified to discuss some of the material,

(3) not worth arguing- a research paper should always make some sort of central claim and your topic should therefore enable you to make a clear, concise claim.

What is a Good Research Problem?

- Well-defined: Would we be able to tell whether you've solved the problem?

- Highly important: Who would really care about the solution to the problem? Does it solve a big pain?

  – **Identify fundamental problems**

  – **Dream big to identify novel application opportunities**

- Solvable: Is there any clue about how to solve it? Do you have a baseline approach? Do you have the needed resources?

- Matching your strength: Are you good at solving this kind of problems?

Solid and High Impact Research

- Solid work:
  - **A clear hypothesis (research question) with conclusive result (either positive or <u>negative</u>)**
  - **Clearly adds to our knowledge base (can we really learn something new from this work?)**
  - **Implications: a solid, focused contribution is often better than a non-conclusive broad exploration**
- High impact = high-importance-of-problem * high-quality-of-solution
  - **high impact = open up an important problem**
  - **high impact = close a problem with the best solution**
  - **high impact = major milestones in between**
  - **Implications: question the importance of the problem and don't just be satisfied with a good solution, make it the best**

Conducting Research

Listed below are several important tips for conducting research and note taking:

- In order to avoid later confusion, begin each section by recording the author's name, book or article title, and page numbers (if relevant).

- As you examine each source, record important or unique notions which you may wish to incorporate within your paper. Make certain to outline the general arguments of each source by including a descriptive heading after the citation. This will aid you in more quickly and easily distinguishing between sources in the future. Additionally, it may be useful to group sources into categories based on more refined topics.

- In order to diminish the risk of plagiarizing, do NOT directly lift phrasing or entire segments of the text from sources without properly indicating that you have done so. If you find it necessary to directly quote an author, clearly indicate what has been copied from the author and record the page number on which this information can be found.

- Remain critical of your sources: Do not assume that an idea or criticism is valid, because it appears in the argument of a single critic or even multiple critics. It is important to remain criticial of your sources and their interpretations. Additionally, it is not necessary to exclude a source with whom you disagree. Recognizing and reflecting on claims in opposition to your own will strengthens your own interpretation.

- There are a wide range of potential sources available to researchers, but not all sources are created equal. In order to ensure your sources are of a high quality, seek sources from respected academic journals and books. It is possible to find valid sources outside of these parameters, however, you should primarily focus on using these resources.

What plagiarism means

A piece of writing that has been copied from someone else and is presented as being your own work; to steal and pass off (the ideas or words of another) as one's own; to use (another's production) without crediting the source; to commit literary theft; to present as new and original idea or product derived from an existing source.

In other words, plagiarism is an act of fraud. It involves both stealing someone else's work and lying about it afterward.

All of the following are considered plagiarism:

- turning in someone else's work as your own
- copying words or ideas from someone else without giving credit
- failing to put **a quotation in quotation** marks
- giving incorrect information about the source of a quotation
- changing words but copying the sentence structure of a source without giving credit
- copying so many words or ideas from a source that it makes up the majority of your work, whether you give credit or not

Most cases of plagiarism can be avoided, however, by citing sources. Simply acknowledging that certain material has been borrowed, and providing your audience with the information necessary to find that source, is usually enough to prevent plagiarism.

Revise Your Outline & Draft

Read your paper for content errors, check facts, arrange and rearrange ideas to follow your outline. Reorganize outline if necessary.

CHECKLIST ONE:

1. Is my paper statement concise and clear?

Make certain that the reader is in no doubt what the idea is. Be 100% explicit:

"The main idea of this paper is...."

"In this section we present the main contributions of the paper."

2. Did I follow my outline? Did I miss anything?

3. Are my arguments presented in a logical sequence?

4. Are all sources properly cited to ensure that I am not plagiarizing?

5. Have I proved my paper with strong supporting arguments?

6. Have I made my intentions and points clear in the paper?

Re-read your paper for grammatical errors. Use a dictionary as needed. Do a spell check. Correct all errors that you can spot and improve the overall quality of the paper to the best of your ability. Get someone else to read it over. Sometimes a second pair of eyes can see mistakes that you missed.

A Research Guide for Research Students
http://www.aresearchguide.com/1steps.html

Revise Your Outline & Draft

CHECKLIST TWO:

1. Did I begin each paragraph with a proper topic sentence?

2. Have I supported my arguments with documented proof or examples?

3. Any unfinished sentences?

4. Any unnecessary or repetitious words?

5. Varying lengths of sentences?

6. Does one paragraph or idea flow smoothly into the next?

7. Any spelling or grammatical errors?

8. Quotes accurate in source, spelling, and punctuation?

9. Are all my citations accurate and in correct format?

10. Did I avoid using contractions? Use "cannot" instead of "can't", "do not" instead of "don't"?

11. Did I use third person as much as possible? Avoid using phrases such as "I think", "I guess", "I suppose"

Critical Thinking

- Develop a habit of asking questions, especially why questions

- Always try to make sense of what you have read/heard; don't let any question pass by

- Get used to challenging everything

- Practical advice

  - **Question every claim made in a paper or a talk (can you argue the other way?)**

  - **Try to write two opposite reviews of a paper (one mainly to argue for accepting the paper and the other for rejecting it)**

  - **Force yourself to challenge one point in every talk that you attend and raise a question**

Respect Data and Truth

- Be honest with the experiment results
  - **Don't throw away negative results!**
  - **Try to learn from negative results**
- Don't twist data to fit your hypothesis; instead, let the hypothesis choose data
- Be objective in data analysis and interpretation; don't mislead readers
- Aim at understanding/explanation instead of just good results
- Be careful not to over-generalize (for both good and bad results); you may be far from the truth

Communications

- General communication skills:
  - **Oral and written**
  - **Formal and informal**
  - **Talk to people with different level of backgrounds**
- Be clear, concise, accurate, and adaptive (elaborate with examples, summarize by abstraction)
- English proficiency
- Get used to talking to people from different fields

Suggested organization of a research paper

- Intro/motivation

- Background and related work

- Overview of my solution

- My solution

- Results

- Concluding remarks

Introduction: 4 parts

- Motivations

- High level view of what others have done and why it's inadequate

- In this paper…

- In the next section …

Background vs related work

- *Background* is a review of information the reader will need to understand your paper
- *Related work* is what other researchers have done

Overview of "*my solution*"

- A **high level view** of the system – works best with a figure!

- Show how the "bits & pieces" fit together

- Can highlight the advantages of your approach

Describing my approach

- Most important thing to remember: *You know it, they don't!*

- Every new word should be followed by a definition

- Picture is worth 1000 words

Results

- Experiments, results, and the case studies.
- Describe the platform, processor, OS, language, compiler, compiler optimizations
- Describe the test data.
- Use tables: describe each row & column
- Sometimes a graph is better than a table

Impact of Results

- How many times did you perform each experiment?
- Validity of results
  - Any weaknesses of the test group
  - Anything important about the approach
- Threats to generalize
  - Can you really generalize: why/why not
  - Is it **automatable** or **automated**?!

Most important!

- Do not claim more than you did
- Do not generalize from one study or result
- Do not claim that because it worked well on a few test cases that it will work well on all test cases, all platforms and for all inputs!

Figures

- Cannot simply "drop" them into paper **(see Figure 3)**

- Writers are immersed in the subject -- readers are not!!

- When referring to a specific Figure/Section/Table, use upper case, otherwise use lower case:

  - **The overview in <u>F</u>igure 3 is better than the other <u>f</u>igures**.

- Should describe each item in a figure: "The icon in the upper left corner of the figure represents…"

- Should motivate the figure: "This figure provides an overview of our system, including input …"

Figures (cont)

- If they contain code, number each line
- Refer to specific lines, or sets of lines, in the text
- Should be either pseudo-code, or language specific (tell them what the language is!)

Conclusions and further work

- Be brief.

Listening to your reviewers

- Read every criticism as a positive suggestion for something you could explain more clearly
- Thank them warmly. They have given up their time for you.