

TECHNICAL COMMUNICATION IN ENGINEERING: writing and oral presentation



LESSON 3

Technical writing

3.1 Introduction.

3.2 Definition of technical writing.

3.3 Writing the text.

3.3.1 Text structure.

3.3.2 Proper use of vocabulary and graphic elements.

3.3.3 How to write and cite bibliographical references.

3.3.4 The writing process and the tools for writing.

3.4 Engineering writing case studies.

3.4.1 Laboratory reports.

3.4.2 Final degree project.

3.4.3 Scientific articles.



Figure 1



3.1 INTRODUCTION

In the present lesson several strategies to improve technical writing in the field of science and technology are provided. Apart from describing the basic structure a technical document should have, several tips are given for the correct use of vocabulary, figures, tables, and references. The lesson also includes a variety of practical activities to work on those aspects considered herein.

LEARNING OUTCOMES

At the end of this lesson we expect the student to:

- Prepare technical reports.
- Use correctly graphic elements within a technical document.
- Organize bibliographical references in a standardized format within a technical document.

3.2 DEFINITION OF TECHNICAL WRITING

- ❑ Technical writing is characterized by two main features:

ACCURACY: The main aim of technical writing is to describe a process, device, experiment, etc. A poor description could cause failure of the device, lack of reproducibility of the experiment, etc.



Figure 2

PURPOSE: Contrarily to non-technical writing (press, poetry, advertising), technical writing does not aim to cause an emotional response on the reader.

- ❑ **Educational:** Its aim is to teach. For example, textbooks.
- ❑ **Theoretical:** Includes theoretical and/or applied studies.
- ❑ **Professional:**
 - **Scientific writing:** Books, articles, conference abstracts, etc.
 - **Technical reports:** Progress reports, viability studies, specifications, manuals, procedures, environmental statements, etc.
 - **Business communication:** presentation letters, communications to human resources, administrative communications, etc.

Technical writing

Educational

Theoretical

Professional

Scientific writing

Technical reports

Business
communication

3.3 WRITING THE TEXT

- ❑ Before writing any document, two important aspects should be considered:

AUDIENCE: Who is gonna read the document needs to be identified. Are they colleagues? Are they experts in a topic? Are they external agents? etc.

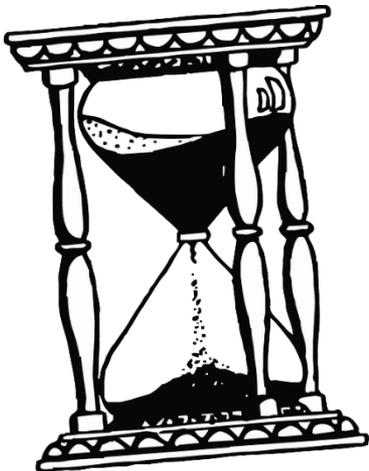


Figure 3

TIME: We should know the deadline to submit the document to organize our time among the different writing stages: think, plan, gather information, write and revise.

3.3.1 Text structure

- ❑ Irrespective of the type of technical document, the following questions should be answered along the document:

Why?

Introduction: The introduction should state the problem, justify the need and, in some cases (e.g., scientific articles), provide information about the state of the art.

How?

Materials and Methods: Here, the details about the employed materials need to be provided. Besides, the employed techniques and methodology are described so the experiment can be repeated by others.

What?

Results, discussion and conclusion: Based on the results obtained, the main findings and conclusions are presented herein.

- ❑ In general, technical documents contain the sections shown in the box below. In some cases, and depending on the document type, some of these sections are modified, deleted and/or combined.

- Cover page.
- Abstract.
- Table of contents.
- Introduction.
- Materials and methods.
- Results.
- Discussion.
- Conclusion.
- Bibliography or list of references.

The title of each section (from “Introduction” to “Conclusion”) needs to be numbered (usually in decimal numbering). The first section (usually the “Introduction”) is numbered with 1. The first subheading would be 1.1., the next one 1.2. and so on. Lower range heading would be 1.1.1., 1.1.2., etc.

The format of each title should be consistent. For example, we could highlight main titles (e.g., 2. Methods) with bold font and size of 14, second-range titles (e.g., 2.1. pH measurements) with non-bold font and size of 12, third-range titles (e.g., 2.1.1. Buffer preparation) in italics and size of 12, etc.

COVER PAGE

❑ The cover page should include the following information:

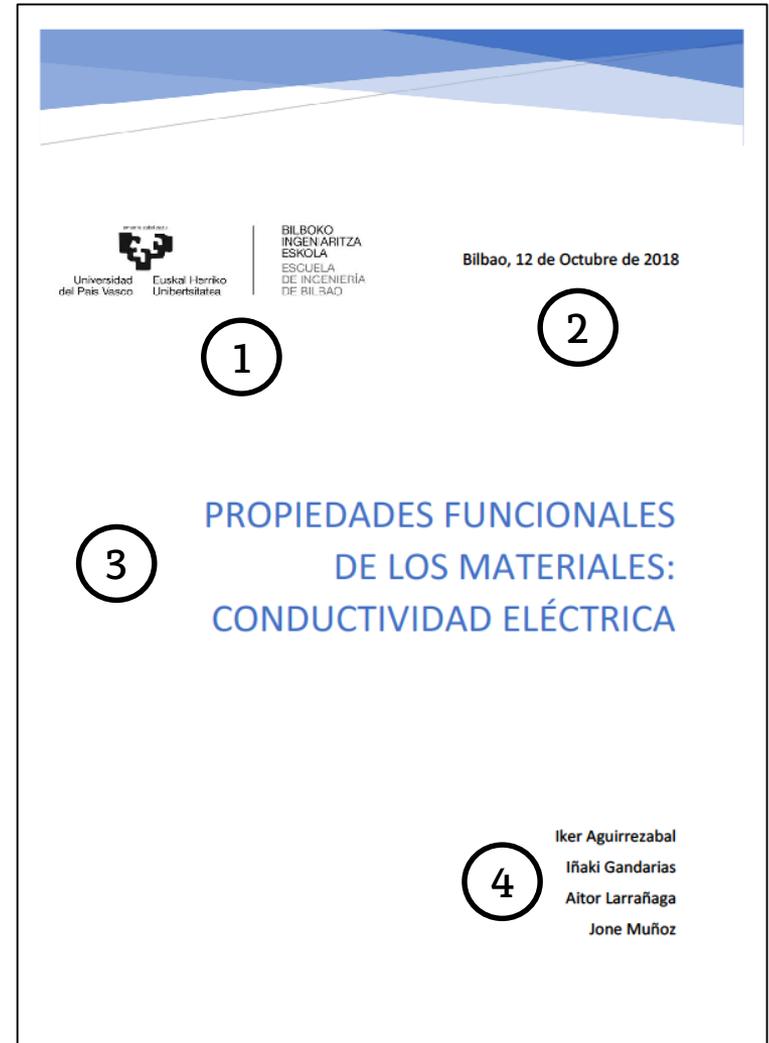
① **Name and logo of the organization:**

It is usually placed on the top left side.

② **Date and place:** It is usually placed on the top right side.

③ **Title:** It is usually placed on the middle. It should draw the attention of the reader by using different font size, colour, etc.

④ **Authors:** It is usually placed at the bottom. The authors are organized in alphabetic order or by contribution.



The cover page does not include page number.

Figure 4

SUMMARY

- ❑ It is **brief** (usually less than 300 words).
- ❑ It should **state the problem**, the methodology (if necessary), main findings and conclusions of the study.
- ❑ It is written in third person.
- ❑ References (bibliography) or any other reference to the main text are avoided → is should **stand alone**.
- ❑ It is recommended to write the summary after finishing with the whole document. It is placed between the cover page and the table of contents. Sometimes, it is placed in the cover page.
- ❑ This section is **not numbered**.

TABLE OF CONTENTS

- ❑ The table of contents should include all the sections and subsections of the document (following the same order and numbering as the one employed in the document), together with their start page. The page where the **table of contents** appears is the first that includes **numbering**. Sometimes an alternative numbering format (e.g., roman numbers) is used.

The image shows a page from a document with a blue header bar containing the text 'DETERMINACIÓN DEL PH EN SUELOS DE LA COMUNIDAD DEL PAÍS VASCO'. Below the header, the title 'Table of contents' is underlined. The table of contents lists the following sections and their corresponding page numbers:

1. Introducción.....	2
2. Materiales y métodos.....	3
2.1. Materiales y reactivos	3
2.2. Recogida de muestras	4
2.3. Determinación del pH	5
3. Resultados	6
3.1. Muestras de Álava.....	6
3.2. Muestras de Bizkaia	7
3.3. Muestras de Gipuzkoa	8
4. Discusión.....	10
5. Conclusiones.....	12
Bibliografía.....	13

1

Figure 5

INTRODUCTION

- ❑ It is the **first section in the document that is numbered**.
- ❑ Both the **problem** and the **reason to perform the study** should be stated here.
- ❑ The **main aim** of the study should be also included in this section.
- ❑ Include the references (bibliography) to establish the problem and the state of the art.
- ❑ In experimental studies, the **hypothesis** to be tested needs to be included.
- ❑ Do not repeat the information given in the “Abstract”.
- ❑ Use a **friendly language** that attracts the attention from non-technical readers.

MATERIALS AND METHODS

- ❑ The procedures described in a technical and/or scientific report should be reproducible by others. However, 70% of technicians/scientists that try to repeat the experiments described by others fail to do so → **reproducibility crisis**.

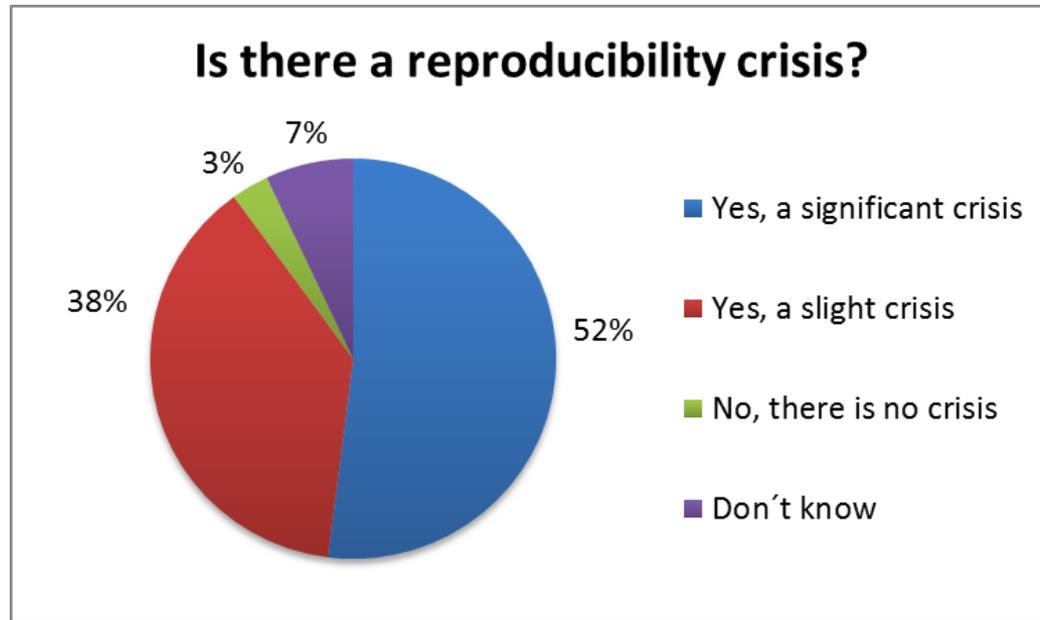


Figure 6

Survey of 1576 researchers about reproducibility of results
(modified from Nature 2016 May 26;533(7604):452-4. doi:
10.1038/533452a.)

- ❑ With the aim of avoiding the “reproducibility crisis” we should:
 - Mention all the details of the employed equipment.
 - Describe in details the experiment or procedure, including all the actions taken to ensure precision and safety.
 - Include previous references where the same procedure has been described, highlighting the changes with respect to them.
 - Describe in detail the reagents employed (purity, supplier, etc.).
 - Use standardized nomenclature for the reagents.

RESULTS

- ❑ In this section the main results and findings should be clearly provided. For that, the use of **tables, graphs and diagrams** is recommended.
- ❑ When the “Results” section is independent from the “Discussion” section, the results should be presented aseptically.
- ❑ Do not include raw data. These data can be included in the “Appendix” section at the end of the document.
- ❑ The tables and graphs need to be presented in a clear way, including statistical whenever it is necessary.

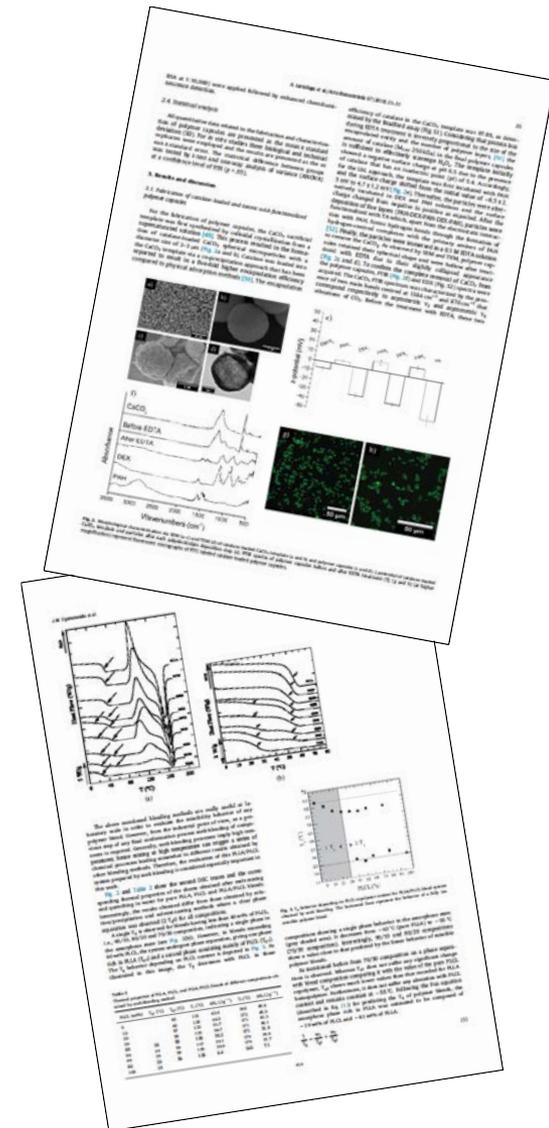


Figure 7

DISCUSSION

- ❑ Sometimes, this section is combined with the “Results” section → “Results and Discussion”.
- ❑ Considering the problem stated in the introduction, the obtained results and the bibliography employed, this section extensively discuss the main findings of the study.
- ❑ **Do not overstate the obtained results.** Perform the discussion based on the facts observed.
- ❑ Whenever a reference from other authors is employed, make sure that the meaning is preserved.



Figure 8

CONCLUSIONS

- ❑ The conclusions is the **last section that is numbered** within the document. This section should summarize in an effective way the story and main findings described along the document.

BIBLIOGRAPHY OR LIST OF REFERENCES

- ❑ Herein, all the bibliographical details of the references employed along the document should be provided.
- ❑ All the references should follow the **same format**. There are various standards (e.g., BS 1629 or ISO 690) that establish the way to present bibliographic references. In any case, we should check the format suggested by the editorial (in case of books or scientific articles) or the company/institution where the document will be published.
- ❑ Check section “3.3.3. How to write and cite bibliographical references” for more information.

APPENDIX (ES)

- ❑ This section provides specific details that are not included in the main document but they may be of some interest for readers:
 - Raw data.
 - Supporting figures.
 - A more detailed description of materials and methods.
 - Etc.

3.3.2 Proper use of vocabulary and graphic elements

PROPER USE OF VOCABULARY

- ❑ English is the preferred language in scientific and technical documents.
- ❑ Irrespective of the language, the technical writing should be characterized for the following features:
 - **CLEAR AND SIMPLE: Avoid the use of long and complex sentences.**
 - **TECHNICAL (but not too much):** Use a technical language to gain credibility, not to impress the audience. In some occasions, the use of a more simple language or **supporting explanations** of very specific aspects is acknowledged to draw also the attention of non-technical readers. Again, we should consider the target audience to adjust the language and content of our document.

- **CONSISTENT:** The use of acronyms, abbreviations, decimal numbers, hyphens, capital letters, etc. should be used consistently along the document. In the case of acronyms, the whole name needs to be described the first time it is mentioned in the document. Alternatively, a **list of acronyms** can be included at the beginning of the document.
- **FREE OF MISTAKES:** As far as possible, grammar and misspelling mistakes should be avoided. A **thorough revision** of the document once finished will help to avoid these mistakes.

- ❑ In the following table some alternatives to superfluous words, circumlocutions and other structures that may difficult the understanding of the document are included.

	Alternative
I am in the process of...	I am...
Most importantly of all,	Most important,
On a theoretical level	In theory
On a regular basis	Regularly
Completely surrounded	Surrounded
Few in number	Few
Quite obvious	Obvious
Real problems	Problems
Each individual person	Each person
A specific example	An example
In two equal halves	In halves
Grouped together	Grouped
Eradicate completely	Eradicate
Give positive encouragement	Encourage

Circumlocution

Superfluous words

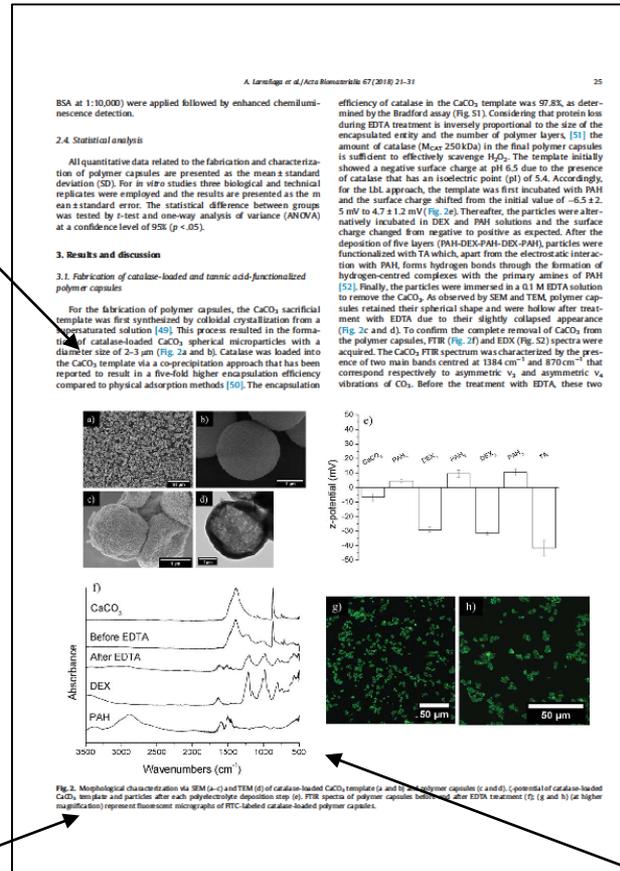
Tautology

GRAPHIC ELEMENTS

- ❑ Graphic elements are tables, figures (photographs, schemes, drawings and graphs), equations, etc. that appear in a document.

- ❑ The following aspects should be considered:
 - They are used to **support an idea**, facilitating its understanding.
 - They “break” the text, making the **document more appealing**.
 - The information should **not be repeated**. For example, the information of a graph should not be repeated in a table.
 - They are **numbered and placed in a relevant place** within the document (usually, immediately after the idea they support) and **called out** in the text.
 - If possible, they should be placed so the orientation of the document is preserved. In other words, the document should not be rotated to observe the graphic element.

The figure is placed in a relevant place and is called out in the text



The figure is numbered and includes a comprehensive caption

Figure 9

Panel of figures

- Below, several tips for the correct use of i) tables, ii) figures and iii) equations are given:

I) TABLES

- They represent an efficient way to show complex data.
- They should be **numbered** independently from the figures. The number of the table appears immediately **above the table**, together with a short description.
- Tables combining too many parameters should be avoided.

Numbering (above the table), together with a short description

Columns are fully described and units are given

Table 1. Elastic modulus for some metals and polymers

Material	Elastic Modulus (GPa)
<i>Metals</i>	
Aluminium	62.0
Copper	128.0
Iron	207.0
Titanium	116.0
<i>Polymers</i>	
Polypropylene	1.5
Polycarbonate	2.0
Polystyrene	3.0
Tefon	0.5

Data, keeping the same format (same decimal numbers)

II) FIGURES

- They should be numbered independently from the tables, indicating the number of the figure immediately below it, together with a full description (caption). The figure with its caption should stand alone (i.e., it does not require the whole document to understand it).
- It is not recommended to finish a document or a section with a figure.
- Take into account that many documents are printed in black&white → avoid the use of too many colours.
- Micrographs should always include a scale bar.

- Planes and maps: include, apart from the scale bar, an arrow that indicates the north.
- Graphics: choose the type of graph (bar chart, line graph, pie chart) that better supports the idea we want to convey. Include the units in the axes, statistical analysis (if necessary), legend and use an appropriate font size.
- Request permission: if the figure to be used in the document has not been developed by the author, complete reference of the figure should be given. In the case of copyright figures, permission to reuse the figure should be requested. Some sources (e.g., creative commons) contain open access figures, free of charge.

Some examples:

Legend

Statistical analysis

Axes with corresponding units

Avoid the use of colours to elude problems when printing the document in black and white

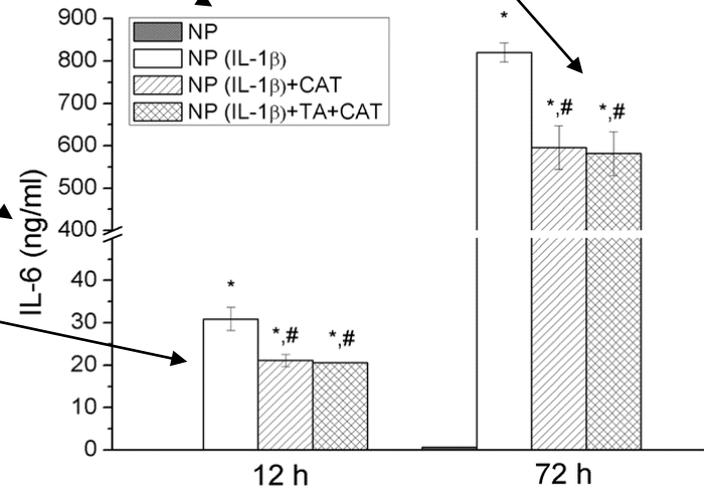


FIGURE 2. IL-6 secretion after 12 and 72 hours. Asterisks (*) and pounds (#) indicate significant differences with $p < 0.05$ and $p < 0.01$, respectively.

Figure 10

Scale bar

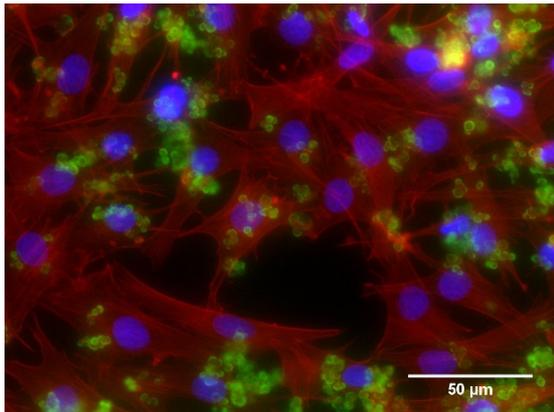


FIGURA 1. HeLa cells in the presence of polymer capsules. Nuclei was stained with Dapi (blue), cytoskeleton with rhodamine-phalloidin (red) and capsules with FITC (green).

Numbering (below the figure) and figure caption.

III) EQUATIONS

- Contrarily to tables and figures, there are not fixed rules to number equations. It is important, however, to keep consistency along the document when numbering equations.
- Contrarily to tables and figures, it is not compulsory to number all the equations along the document. Just those equations that are referred in the text are numbered.
- For equations showing terms that have not previously appeared in the document, these terms need to be specified immediately after the equation.
- There exist several tools (Microsoft Equation Editor, MathType, LaTeX) that help us to create and edit equations.

For example:

The elastic modulus of the composite material was calculated based on equation (3):

$$E = \Phi_{\alpha} E_{\alpha} + \Phi_{\beta} E_{\beta} \quad (3)$$

Where E is the elastic modulus of the composite material, Φ_{α} and Φ_{β} are the volume fraction of each phase and E_{α} and E_{β} are the elastic modulus of each phase.

3.3.3 How to write and cite bibliographical references

- Whenever a technical document is written, it is necessary to include references along the text to describe the state of the art or the problem to be solved.



Figure 12

- ❑ Several aspects need to be considered when selecting the references to be cited:
 - Do not use too many **web references**. In comparison to other sources (books, articles, etc.), they are not so reliable (see Lesson 2).
 - Avoid the use of too old (>10 years) references, particularly in those fields that change very quickly. In contrast, be sure to include “classic” references (i.e., those pioneering works in the field).
 - The use of **bibliographic managers** (EndNote, RefWorks, Mendeley, etc.) is highly recommended to facilitate the organization and management of references (see Lesson 2).

- ❑ There are several styles to cite references: *American Psychological Association (APA)*, *Modern Language Association (MLA)*, *American Institute of Physics (AIP)*, *Institute for Electrical and Electronics Engineers (IEEE)*, etc.
- ❑ Whenever we have to cite a reference or fill the “Reference list” or “Bibliography” section, it is important to **check the style** recommended by the editorial or institution where we plan to submit our work.
- ❑ Here, by way of example, one of the most commonly employed styles in scientific and technical documents will be described: *Vancouver style*.
- ❑ As previously mentioned, in case we want to use a different style, we should check the accepted format to cite references along the document and to fill the “Reference list” or “Bibliography” section

□ Citations in the text:

- Along the document, whenever we want to cite a previous work, an arabic numeral (1, 2, 3, 4...) is placed immediately after the sentence to cite.
- This number can be placed in brackets (1) or square brackets [1]. Alternatively, superscripts can be used ¹.
- This number can be placed before or after the punctuation mark.
- Although several options are available within this format, it is important to be consistent along the document and to use always the same format..
- In case more than one reference is cited, hyphens or commas can be used to group the references: (1, 5, 6-8) → In this case, references 1, 5, 6, 7 and 8 are cited.

As it was observed in previous studies, [1] the use of pesticides has a detrimental effect in wetland water. Thus, several alternatives to the traditional irrigation method have been proposed, including drip irrigation (2), sprinkler irrigation or solar irrigation³⁻⁵.

As it was observed in previous studies, [1] the use of pesticides has a detrimental effect in wetland water. Thus, several alternatives to the traditional irrigation method have been proposed, including drip irrigation ,[2] sprinkler irrigation or solar irrigation.[3-5]

In both cases, Vancouver style was employed. However, in the first case the text is not consistent with the employed format, thus being incorrect.

❑ Bibliography or List of References

- In the List of References, the references appear in numerical order, following the same order as the one employed along the text.
- It is recommended to start the List of References section in a new page, with the “Bibliography” or “List of References” heading.
- The list must include all the references cited in the text. New references that do not appear in the text cannot appear in this list.
- Include the surname of the author followed by his/her initials. For those works developed by 1-6 authors, give the information of all of them, separating them by a comma. For those works with more than 6 authors, give the information of the first 6 authors and then add et al.
- After the details of the authors, include the title of the work. Be consistent in the use of capital letters. For example, use capital letters only in the first word of the title.

- After the title, indicate the name of the journal where the document was published. It is recommended to use the abbreviated name of the journal. (<https://www.ncbi.nlm.nih.gov/nlmcatalog/journals>).
- Finally, include the year, the volume and number of pages (Year; volume; pages).

Articles with 1-6 authors:

1. Petitti DB, Crooks VC, Buckwalter JG, Chiu V. Blood pressure levels before dementia. Arch Neurol. 2005; 62: 112-116.

iv) Year; volumen: pages

i) Surname of all the authors, together with their initials

ii) Title of the work

iii) Abbreviated name of the journal.

Articles with more than 6 authors:

14. Hallal AH, Amortegui JD, Jeroukhimov IM, Casillas J, Schulman CI, Manning RJ, et al. Magnetic resonance cholangiopancreatography accurately detects common bile duct stones in resolving gallstone pancreatitis. J Am Coll Surg. 2005; 200: 869-8753

Books:

8. Carlson BM. Human embryology and developmental biology. 4th ed. St. Louis: Mosby; 2009. 541 p.

v) Pages.

ii) Title of the book.

iii) Edition.

i) Surname and initials of the author(s).

iv) Place; year.

Book chapters:

25. Blaxter PS, Farnsworth TP. Social health and class inequalities. In: Carter C, Peel JR, editors. Equalities and inequalities in health. 2nd ed. London: Academic Press; 1976. p. 168-178.

iv) Title of the book.

v) Edition.

iii) Surname and initials of the editor(s).

i) Surname and initials of the author(s).

ii) Title of the chapter.

vi) Place; year. Pages of the chapter

Web references:

6. Australian Medical Association [Internet]. Barton ACT:AMA; c1995-2012. Junior doctors and medical students call for urgent solution to medical training crisis; 2012 Oct 22 [cited 2012 Nov 5]; Available from: <https://ama.com.au/media/junior-doctors-and-medical-students-call-urgentsolution-medical-training-crisis>

i) Web title [Internet]

v) URL

ii) Place of publication:
Name of the editor

iii) Year

iv) Specific title of the webpage;
year of publication of the webpage.

3.3.4 The writing process and the tools for writing

- ❑ Before writing a document by using a word processor (e.g., Microsoft Word, OpenOffice Writer, LaTeX, etc.), it is recommended to spend some time **giving format** to the document to preserve the consistency. Moreover, some of these tools are very helpful to save time when editing the document.

- ❑ Here, some common tools employed in word processors will be explained. As an example, the word processor “OpenOffice Writer” will be employed because it is a free software. The following aspects will be described:
 - Basic tools.
 - Page numbering, headers and footers.
 - Automatic numbering of tables and figures.
 - Styles.
 - Automatic insertion of the Table of Contents.

BASIC TOOLS



Figure 13

- ① Font style: For scientific and technical documents, the most commonly employed font styles are Arial or Times New Roman. Alternative styles such as Calibri or Cambria can be also employed.
- ② Font size: Usually, a font size of 10-12 is employed along the body of the document. Sometimes, a larger font size (14) is employed for headings.
- ③ The use of **bold** letters, *italics* or underline is common to highlight a sentence or a word within the document. However, excessive use of this tool is not recommended.
- ④ Text alignment: The text should be justified so the left and right sides of the text block both have a clean edge.
- ⑤ Spacing: Spacing should be appropriate to ensure the legibility of the text. However, leaving too much space between lines is not recommended to avoid blank spaces. A spacing of 1.5 is usually employed.

PAGE NUMBERING, HEADERS AND FOOTERS

For some documents, the insertion of a header is recommended. This header is kept constant along the whole document so it should contain general information about the document: logo of the institution, title of the work, name of authors, date, or similars.

It is recommended to number the pages, preferably with Arabic numbers.

All these tools are available within the "Insert" menu: Insert-Header and Footer, Insert-Page number.

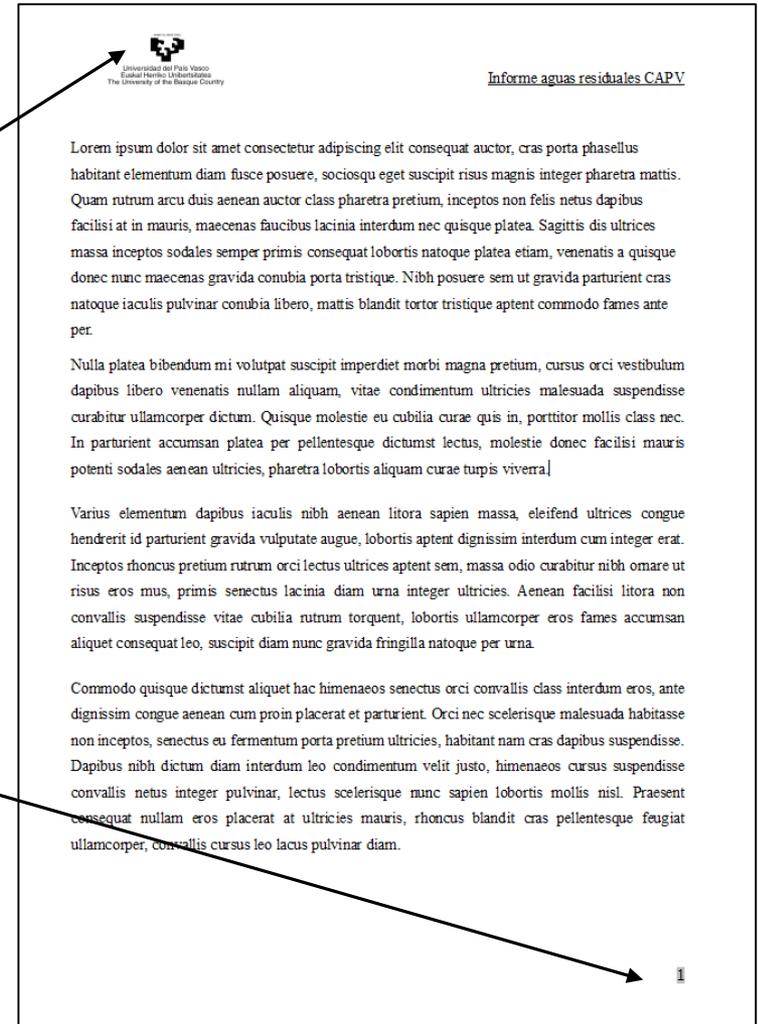


Figure 14

AUTOMATIC NUMBERING OF TABLES AND FIGURES

- ❑ This tool is very useful to keep the format consistent along the document. Besides, since it represents an automatic numbering system, the fields are updated automatically whenever a figure/table is inserted/moved/deleted.

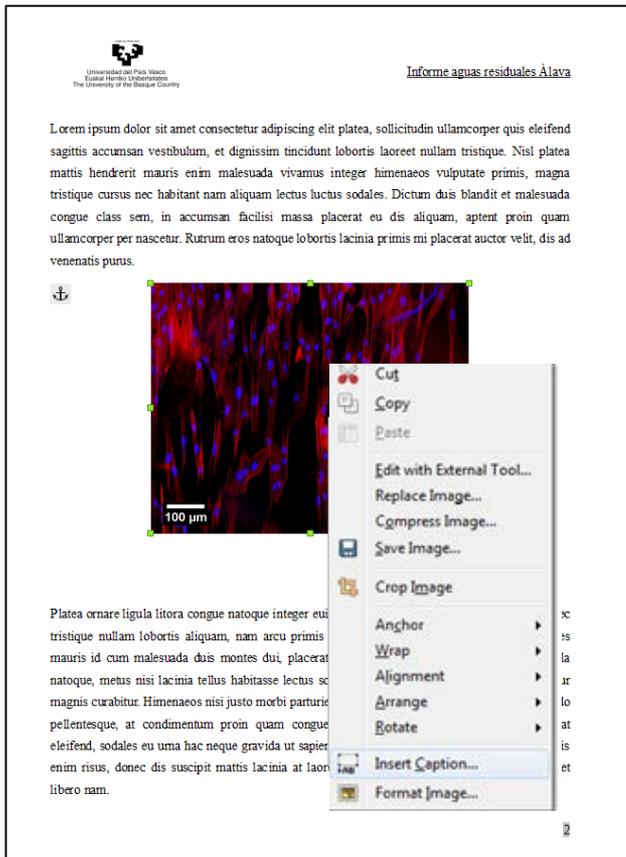


Figure 15

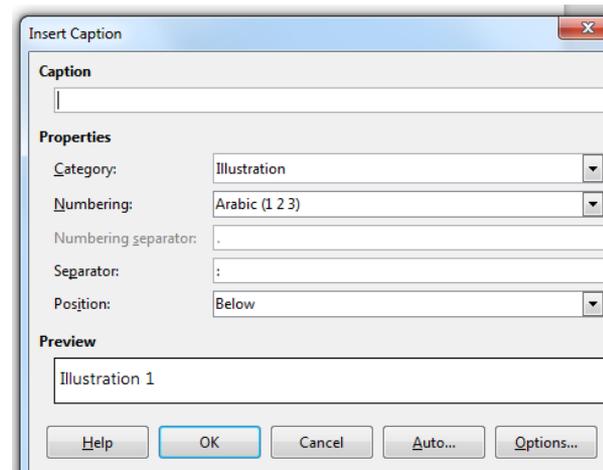


Figure 16

Right click in the figure and select “Insert caption”, so a new box appears. Here, a category for the graphic element (figure, table, illustration, etc.), numbering style, caption, etc. can be selected. Remember that tables are numbered immediately above the table, while figures are numbered immediately below the figure. It is also important to note that tables and figures are numbered independently from each other.

STYLES

- ❑ The use of styles is very useful for two reasons:
 - i) It allows us to keep the format consistent along the document.
 - ii) It facilitates enormously the automatic insertion of Tables of Contents.
- ❑ Before we start writing the document, it is recommended to set the main styles for the main headings, subheadings, text body, etc. By default, the word processor provides several standard styles. It is also possible to create new styles with their own features.
- To do so, in the “Styles” menu, choose “New style” and provide a suitable name for it. For example “Main heading”, “Subheading1”, “Subheading2”, etc. to refer to headings of different grade.
- Then, in the “Styles” menu select “Edit style”.
- A new box appears where the style can be edited: alignment, font style, tabs, spacing, etc.
- Once all the styles have been established, each section of the document needs to be assigned to each style.

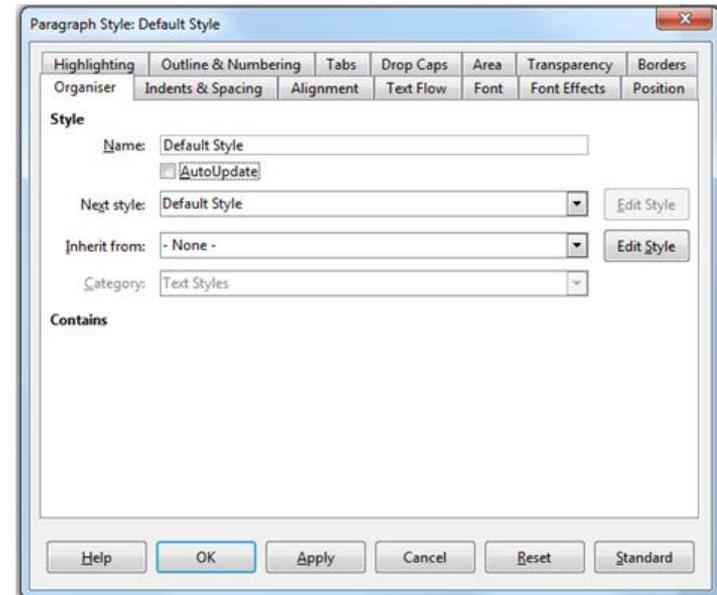


Figure 17

AUTOMATIC INSERTION OF THE TABLE OF CONTENTS

- ❑ If styles have been employed along the document, it is possible to include automatically the table of contents. To do so, go to “Insert-Table of contents and index-Table of contents, Index or Bibliography”.
- ❑ If alternative styles are employed, the grade of each style needs to be established.

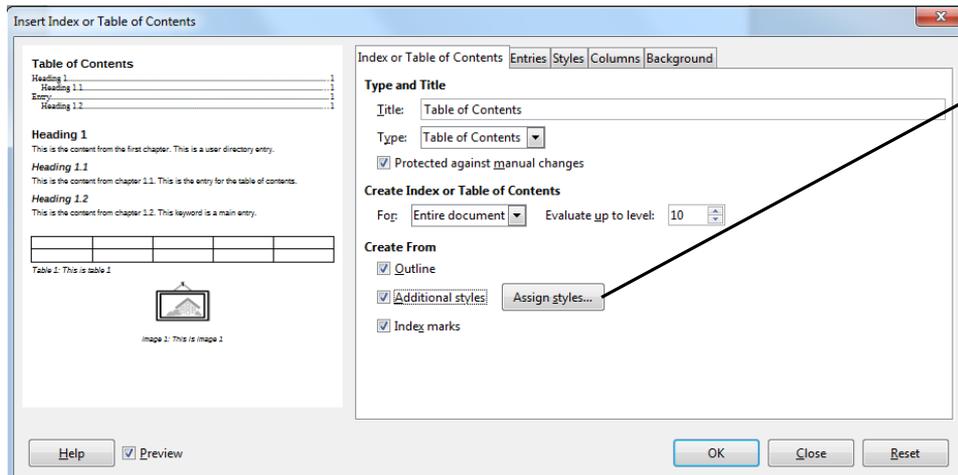


Figure 18

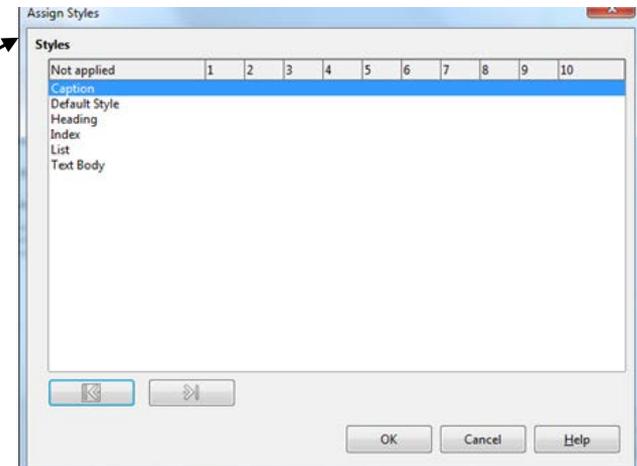


Figure 19

- ❑ To do so, go to “Assign styles...” and then establish the grade for each style.
- ❑ One of the main advantages of inserting the Table of contents automatically is that the fields will be **updated automatically** whenever a change is made in the document. This is particularly useful for long and complex documents.

3.4 ENGINEERING WRITING CASE STUDIES

3.4.1. Laboratory reports

AUDIENCE AND OBJECTIVES

- ❑ A laboratory report is usually addressed to the lecturer that evaluates the subject. In any case, the laboratory report should include all the necessary information to understand the background, objectives, results and conclusions of the work. The lack of important information could have a detrimental effect on the quality of the report.
- ❑ Thus, the laboratory report should be written as the target audience is of a similar profile to the author (i.e., a student). With this perspective, the report should have all the details of the practical work that allows other students to understand the practical work even without having performed it.
- ❑ The main aim of a laboratory practice is to use in a practical case the theoretical knowledge acquired previously. In this way, the laboratory report should reflect all this knowledge in a clear and concise way. Besides, the laboratory report should have enough detail to allow others to reproduce the laboratory practice [1].

TIPS TO FOLLOW DURING THE PRACTICAL WORK FOR A GOOD REPORT

- ❑ The aim of the report needs to be clear, so the practical work should be designed to answer the following questions: which topic are we dealing with? why are we using that specific procedure? what do we learn from this particular practice?
- ❑ The laboratory practice should be analyzed beforehand to predict unexpected issues and be as effective as possible.
- ❑ Data should be collected in a rigorous way and including as many details as possible. In this way, it will be possible to describe the important facts more precisely in the written report.
- ❑ Discuss with the lecturer and the colleagues to compare our data and check the results.
- ❑ A laboratory report is usually written in groups so the effective exchange of information between mates is necessary.



Figure 20

LAYOUT

- ❑ The layout of the report is divided in different sections [2]:

TITLE

AUTHORS

SUMMARY

INTRODUCTION

METHODS

RESULTS and DISCUSSION

CONCLUSION

LIST OF REFERENCES



Figure 21

□ There are 4 main sections in a laboratory report:

1. INTRODUCTION

- Includes detailed information about the topic, background and references.
- It links the practical work to the theoretical knowledge previously acquired.
- The aim of the practice and the report should be stated.
- Includes the hypothesis of the practice.
- It justifies the hypothesis.
- A short summary about the content and the layout of the report is presented.

2. METHODS

- The details of the materials are described here.
- It describes in detail the experimental procedures and conditions employed.
- Rational use of the information to ensure its reproducibility.
- Past tense and third person writing is recommended.

3. RESULTS and DISCUSSION

- The results can be depicted through figures, tables, diagrams, etc.
- The text should describe the information illustrated in the figures or tables and also explain the observed trends.
- The results should not be repeated in the text and figures.
- The discussion implies an assessment of the obtained results; it needs to be justified and also referenced.
- The use of data management tools (e.g., Microsoft Excel, Origin, SPSS) is helpful to provide the results in a more attractive way.

4. CONCLUSIONS

- A link between the objectives and the results should appear here.
- The conclusions have to summarize the technical aspects and the knowledge acquired.

3.4.2. Final degree project

AUDIENCE AND OBJECTIVES

- ❑ The final degree project comprises the development, presentation and public defense of a project or original work, in which the student states the competences acquired along the degree and his/her capacity to apply them [3].
- ❑ It is considered to be the final step within a degree program, since the student presents here the most important individual work of his/her academic career [4].
- ❑ These projects should be focused on the development of a research, work or innovation in the professional field.
- ❑ The audience is the evaluation panel, which usually comprises three or more lecturers of the Faculty of Engineering.



Figure 22

LAYOUT

- ❑ Each Faculty of Engineering usually provides a standard layout for this document. In the Faculty of Engineering in Bilbao, there are three categories:
- ❑ **Traditional projects.** The project gives response to a need through a document that allows the development of an instrument, plant, installation, software or any other activity related to engineering.
- ❑ **Development of an idea or prototype.** The project covers the theoretical modelling of instruments or systems that provide new solutions to the techniques employed in the technology applied to engineering.
- ❑ **Technical, organizational, economic, informatic and research studies** that affect the fabrication processes, instalations or services that depend on the technology related to the topic of each degree.

□ The layout is divided in the following sections:

- Cover page.
- Summary + keywords.
- Table of contents, together with the List of tables, illustrations, graphics and acronyms.
- **MEMORY**
 - Introduction
 - Context
 - Objectives
 - Benefits
 - Description of the requirements and/or state of the art
 - Alternatives
 - Risk analysis (if necessary)
 - Choice/Description of the provided solution
 - Design (basic or high level)

- **METHODOLOGY EMPLOYED IN THE DEVELOPMENT OF THE WORK**
 - Describe the tasks, phases, instruments or procedures
 - Gantt chart
 - Calculations, algorithms (depending on the case)
 - Description of the results
 - Project plan and planning

- **ECONOMIC ASPECTS**
 - Description of the budget and/or budget executed
 - Analysis of rentability

- **CONCLUSIONS**

- **BIBLIOGRAPHY**

- **APPENDIX I: Specifications. Standards. Test plan.**

- **APPENDIX II: Plans, schemes, detail design, code**

- **APPENDIX III: User manuals or administrator manual**

3.4.3. Scientific articles

AUDIENCE AND OBJECTIVES

- ❑ The scientific article represents the culmination of the scientific method. Once the experimental work has been performed with the aim of demonstrating the hypothesis, the results have to be spread to contribute to the state of the art.
- ❑ Scientific papers are the main way to promote communication between researchers, helping science to move along.
- ❑ Scientific papers are usually published in scientific journals of diverse specialization, grade and impact.
- ❑ In general, the audience is comprised of scientists/researchers with some knowledge in the topic.

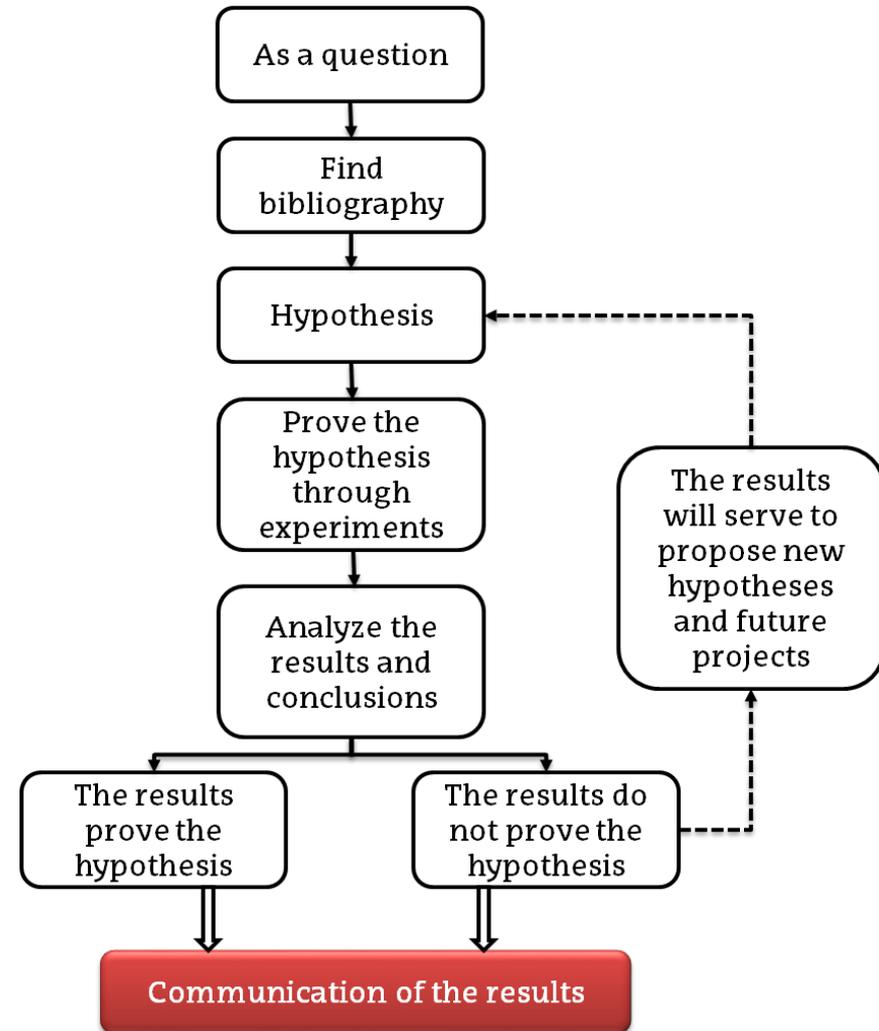


Figure 23

LAYOUT

- ❑ Both the layout of the article and the style of the bibliography will be specified in the “guide for authors” for the specific journal.
- ❑ In general, the layout of an article is as follows:
 - **Title of the article:** it should be concise and include those words that faithfully describe the work performed.
 - **Authors and affiliations,** indicating the corresponding author.
 - Abstract.
 - Keywords.
 - **Introduction:** it describes the state of the art, justifies the reason to perform the study and describes how the document is organized.
 - **Materials and methods** (more and more journals move this section to the final part of the document): it provides a detailed description of the materials and processes to ensure its reproducibility.

- **Results** (in some occasions, this section is combined with the discussion): the use of graphical elements is recommended to facilitate the understanding of the results.
- **Discussion.**
- **Conclusions.**
- **Acknowledgments.**
- **List of references.**
- **Supporting information**, which includes information to support the article (e.g., more detailed description of some sections, additional figures/tables, videos, etc.).

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BASIC TEXTBOOKS

- ❑ Gastel B. y. Day R. A. *How to Write and Publish a Scientific Paper*. 8^a ed. Cambridge: editorial Cambridge University Press; 2017
- ❑ Berger R.E. A. *A Scientific Approach to Writing for Engineers and Scientists*. 1^a ed. New Jersey: Editorial John Wiley and Sons; 2014

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