How to Write an Effective Research / Review Papers

Dr. Ighodalo F. Ijagbone

Nigerian Institute of Science Laboratory Technology (NISLT), Samonda, Oyo State, Nigeria

INTRODUCTION

Definition

A report has been described as an account of something. And when that something relates to either science or technology or both, the account is called a technical or scientific report. Reports in their many forms seek to convey specific information and explanation of a particular subject or problem. A written and published report describes ***original*** research results.

The dissemination of research results and findings is an integral part of research process. Researchers write to ***keep records*** of their work for themselves but more importantly also for the ***readers*** and ***peer researchers*** who are expecting a ***standard form*** ***languag***e, and ***style*** when reading research papers.

A scientific paper has to meet requirements regarding ***how*** the paper is written and the way it is published. It must be a valid publication i.e. it must be published in a peer reviewed journal in the respective field for it to be recognised.

An acceptable scientific publication must disclose sufficient information to enable peers:

- assess observation
- repeat experiments
- evaluate intellectual processes

Furthermore, scientific papers:

- help to advance knowledge
- serve as permanent records as sources for references and decision making
- support the progression of professional career
- pass uniform information and

- make someone famous.

Once a paper is drafted, written, rewritten, and finished it deserves to be published validly. However, dealing with publishers, their editors, peer reviewer's comments, deadlines, submission of deadlines, and other obstacles on the way to the paper appearing in a printed volume can be one of the most time consuming and exhaustive tasks in a researcher's life. Therefore this presentation is to outline the basic approach to writing research paper (scientific report) for publication.

REASONS FOR PUBLICATION

Researchers have to write down what they have been doing, or what they are currently working on for three obvious reasons:

- To remember, because once something is forgotten, it cannot be reproduced correctly without having written notice.
- To understand as writing about a subject can only be accomplished by approaching the subject in a structured way, which itself leads to better understanding thereof.
- To gain perspective, as writing includes looking at something from different points of view.
- Still, it may be asked why researchers have to turn their writing into formal papers. Writing for others is more demanding than writing for oneself but it can help to get a better understanding of own ideas.

BENEFITS

Additional motivations to write and publish research work are:

i. Scientific communication; this is essential if science is to progress
ii. Ideal protection of intellectual property
iii. Legal protection of intellectual property
iv. Gain of reputation is certainly desirable.

Other reasons for writing down and publishing research results include among them as:

i. You have some results that are worth reporting
ii. You want to progress scientific thought
iii. You want your work to reach a broad audience
iv. You will improve your chance of promotion
v. It is unethical to conduct a study and not report the findings.

To be able to express all these in writing and be understood is a great task and he who knows how to write effectively becomes a leader and exerts great influence in society.

COMMUNICATION

How do you communicate? Or what is the tool of communication?

TOOL FOR COMMUNICATION

Language is the main tool of communication in whatever field of study, region of the world, or age one may find oneself in.

Without this tool, neither society nor any form of intellectual pursuit can exist.
Language can be spoken or written. Written language is derived from spoken language. Writing forms **permanent records of information.**

STRUCTURE OF LANGUAGE
Language is structured along:

Phonology	-	Pronunciation
Syntax	-	Grammar (structure) and
Sematics	-	Meaning

ENGLISH LANGUAGE
The basic language we use in this part of the world is ***English Language.***
English is an international language for intellectual pursuit and science.

MEDIUM OF EXPRESSION
Scientists should recognize the relationship between their subject of study and its medium of expression.

Elements of Language
Language (either spoken or written) can be studied at different levels, mainly at the level of speech, vocabulary and grammar.

SCIENTIFIC COMMUNICATION
Our focus is on scientific communication and most scientific communication takes place in writing.

PLANNING
To write well, it is first necessary to plan. Effective writing is systematic with **words** arranged in a logical order and in the right proportions. But before you can start planning you must have something to say, a message to describe.

COMMUNICATION PROCESS
The elements involved include:
- The sender (Writer)
- The message (Report)
- The media of communication
- The receiver (Audience)

UNITS OF THOUGHTS / EXPRESSION
Alphabets
Words
Numbers
Phrases
Clauses
Sentences
Paragraphs

Compositions

TOOLS FOR REPORT WRITING
These are the tools of scientific report writing. You must know their nature, structure relationship to one another and their relative position in compositions.

WORDS
The word (may be a single alphabet or group of alphabet) put together in a specific order so as to have meaning. Choose the right word, the best word you will become a better writer.

STRUCTURE OF CONTENT
The words combine to form **sentences** that communicate messages; they in turn combine in a special way to form **paragraphs**.

In technical reports, and indeed in any composition, the paragraph is the most organised, basic unit of discourse, carrying information as well as showing the relationship of the sentences to each other.
Paragraphs make up **compositions.**

DIFFERENT WAYS OF COMMUNICATING (WRITING)

i. Narrative – is a sequence of events recounted either in the order in which they happened, or in an order chosen to emphasise certain aspects of the story.
ii. Description – saying what something looks like. Descriptive writing deals with appearances what things look, sound, feel, taste or smell like. Observation and selection are key skills in effective descriptive writing especially in S**cience and Technology.**
iii. Exposition – involves explanations. It may require the description of patterns, accounting for how things works, how processes take place or a make theoretical analysis of situation.
iv. Argumentation – requires the expression of one or more points of view, offers to persuade or influence others. It usually requires the writer or speaker to give an explicit or implicit explanation for the views expressed, based on evidence and / or reasoning.

A written text will involve a mixture of two or more of these modes of discourse.

Style
General characteristic
scientific communication places values on some main issues.

Selectively – careful choice of words can enable you to convey the right message.
Accuracy – check that everything you write is factually accurate. The facts should be capable of being verified. Moreover, arguments should be soundly based and your reasoning should be logical. You should not write anything that misinform, mislead or unfairly persuade your readers. If you do, you will be doing a disservice not only to yourself but also to your employers and profession.

Accurate information is essential for effective communication and decision making. It is easier to write honestly and fairly. This makes for an enhanced reputation and a growing confidence in the reliability of your findings, conclusions and recommendations.

Objectivity – A report should not reflect personal emotions and opinions. Decisions should be based on the results, the evidence, or an interpretation of the evidence.

Conciseness – Report should be kept concise and contain all the essential details. Sentences should not be wordily average of about twenty words recommended.

CLARITY AND CONSISTENCY

The best way to achieve clarity in your writing is to allow some time to elapse between the first draft and its revision. Try to have it over the weekend, or at least overnight.
Concentrate on a mental picture of your **readers**, and make sure you are writing for them and not for yourself.

Simplicity – usually if your writing is selective, accurate, objective, concise, clear and consistent, it will also be simple as it can be.

Choosing your words carefully

Prefer plain words – write to express, not to impress. Prefer words your readers are likely to understand.

Avoid pointless words – Phrases like basically, actually, undoubtedly, each and everyone of us, during the course of investigation can be left out since they add nothing to the message.

Avoid overwriting and padding – weed out any meaningless, excess words.

Avoid redundant words – saying the same thing twice in different words should be avoided.

Prefer English to foreign words and phrases. Using uncommon foreign terms like inter alia, per sa etc. may look like showing off. Avoid them unless there are no good English equivalents – and unless you are sure that your audience will understand them.

To write, you move through three imperative stages:

a. Pre-writing
b. Writing
c. Re-writing stage.

Pre-writing stage

You have two major tasks to perform:

i. brainstorming
ii. Outlining

Brainstorming

During the brainstorming you think and stimulate your brain to yield all knowledge that has been accumulated over time from observations, experiences, discussions, research, lectures, and seminars/symposia. Ideas generated should be jotted down as they occur to you.

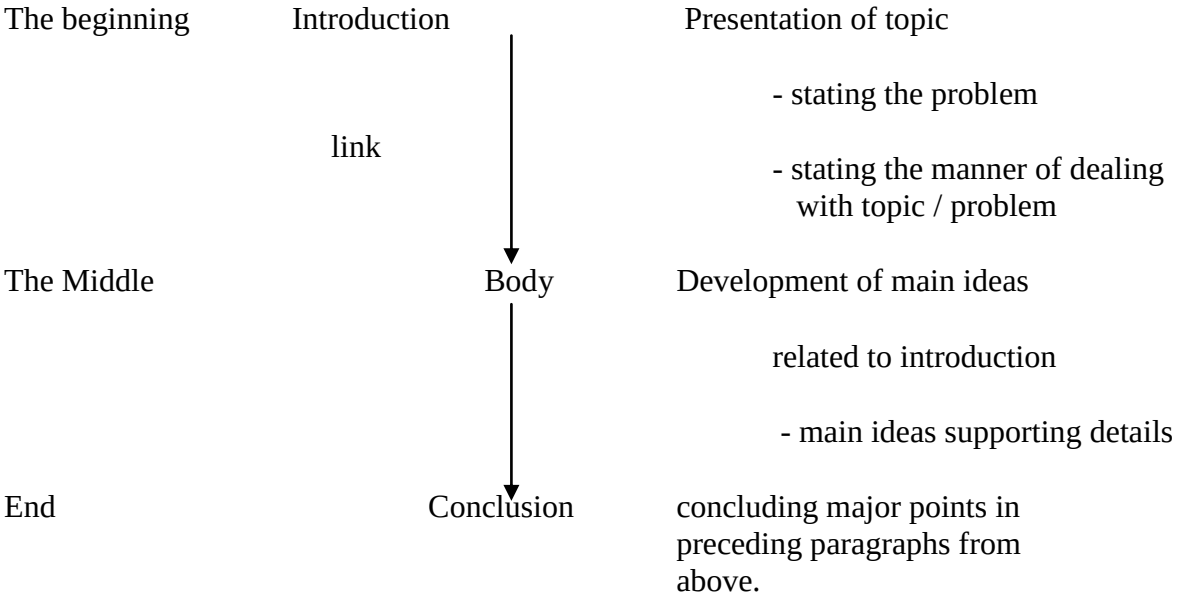
Outlining

Outlining is a formal plan for an essay. It is usually numbered according to the logical presentation of ideas.

Writing stage – this involves making a draft of ideas outlined in the pre-writing stage. Your draft is presented in paragraphs.

Re-writing stage – The final stage of writing your report will involve you in revising and editing your draft with a view to improving your skill. Read your draft slowly, looking at each sentence structure and the meaning it conveys, whether it is precise or not. Put yourself in the position of the reader and judge your essay critically.

Structure of the Report (essay) – Structure simply means the way something is arranged or organised. The essay has a tripartite structure – i.e. any piece of writing must have a **beginning**, a **middle** and an **end.**



FORMAT AND STRUCTURE OF JOURNAL ARTICLES

- Only generalized format can be presented here, because scientific journals and even some specific disciplines prefer different formats and/ or writing styles.

- The suggested guidelines in this paper will only enable you to adapt easily to most journals. The guidelines (and others presented in this Workshop) are necessary tools of learning the scientific writing style and format, but not sufficient to make you an accomplished writer.

- The simple rule is that you practice writing and thinking within the structure, and learn by example from the writing of others in your disciplines.
    - Learning the nuances of preferred style(s) and format(s) of writing will be enhanced as you read the scientific literature.

- Improvement in your own scientific writing skills will come by repeatedly practicing reading, writing and critiquing of other peoples writing.

BEGINNING THE PROCESS OF WRITING

i. *Find a journal article*
   - The first thing you must do is to look for a journal article that is most appropriate for your intended paper. The University library and the Internet will be useful sources.

ii. *The purpose of the scientific paper*
   - You must ask yourself "What is the purpose of science?" Science attempts to answer questions with a view to explaining the world around us.

There are two main ways that a scientist can accomplish this:
   - **The hypothesis** – A hypothesis is an educated guess. After observing an interesting event in nature, a scientist questions that event and attempts to come up with an explanation based on previous knowledge.
     - The scientific paper will now revolve round the hypothesis.
     - You must first introduce the hypothesis to the reader, and then explain the methods employed to test the hypothesis. The results obtained will be presented and discussed on how the results proved or disproved the hypothesis.

The question (objective)
- In most basic science disciplines, you only have a question, which you are trying to solve.
- In this case, a reasonable hypothesis is not possible or applicable.
   - Here you design your experiment and write your paper in order to answer the question. The idea is the same.

JOURNAL STRUCTURE

- Usually, journal articles in the sciences are divided into five parts:
   - **abstract**,
   - **introduction**,
   - **results**,
   - **discussion** and
   - **conclusions**.

ABSTRACT

- As earlier mentioned by other speakers, although abstract is presented first in the text, it should be written last.
- The idea of the abstract is that your audience can quickly read through it and determine if they want to spend more time reading the entire article.

Main items that are essential in the abstract are:
- The purpose. Briefly state your reasons for carrying out the experiment.
- The general method. Do not go into details here. Just state the general techniques such as "isolation was made…" rather than "samples were serially diluted and inoculation was done on appropriate media…." (for Microbiologists). For chemistry researcher,

techniques such as “titration” rather than specifics written as “100 ml of 1M NaOH were titrated with…” will be preferred.
- The main results. Just present the ones that are directly related to your hypothesis/questions
- The main conclusions.

INTRODUCTION

- This is where the hypothesis/question are introduced to the audience.
- Here the reader must be informed what observation the hypothesis is attempting to explain.

The main items expected in the introduction are:

- State the question/objective. What is the question you are trying to answer? What observations are you trying to explain?
- Importance.
  - Why should your audience care about the answer to your question? Include real world applications here.
    - For example, studying chemical reactions in the laboratory is not “attractive” enough. We know chemical reactions are taking place around us all the time. Plants turning sunlight into energy is a chemical reaction, but studying this phenomenon in the laboratory will increase our understanding of photosynthesis.

- Previous work.
  - What has been done on this subject in the past? Do not just state previous works, but you must explain how they are related to your research objective?

- State the hypothesis.
  - What is your answer/explanation to the above question?
    - Remember that the hypothesis/question/objective is just a possible explanation and not a definite answer.

- Rationalize the hypothesis.
  - In other words, based on current scientific knowledge, why have you chosen the hypothesis?
  - Describe possible/expected outcomes.

METHODS.

- This is different from the “Materials and Methods” section.
- Here you must state the general method you have chosen to answer the objective of your research (e. g phenotypic characterization of your isolates; spectroscopy) and explain why the method was chosen.
- If you are carrying out an experiment where you want to find the concentration of ion in solution by spectroscopy, why spectroscopy and not titration method?
- Theory.
- Some intended journal articles are more theoretically based than others.

- Therefore, the amount of theory that will be included in the introduction will vary depending on the emphasis of the article.
- Again, let us refer to using spectroscopy to determine concentration. The emphasis is on the concentration of the sample, so you do not have to go into great depth about the theory of spectroscopy.
- On the other hand, if you had a system that gave a strange spectra and the objective of your study was to explain why this spectra is different than expected, you will have to go into more depth of the theory of spectroscopy.

- In both examples, you must provide enough theory in order to explain the basic concepts behind your work.
    - Your audience needs enough theory to be able to understand your arguments.
- For researchers in the physical sciences, any specific equations that will be needed to complete the research objective should be included here.
    - You should also present derivations of equations that you will need in this section.

MATERIALS AND METHODS

- This section can sometimes be referred to as "Methods" "Experimental or Theoretical Methods".
- Here, you must describe what you did in the laboratory in enough details so that a scientist reading your article can repeat your experiment and obtain exactly the same results.

Repeatability of experiments is an important aspect of science.

- Important points to note when writing this section include:
- Narrative of the procedure
- Materials used.
    - You need to tell the readers what chemicals (name, formula, manufacturer, purity) and instruments (manufacturer, model number) were used so that they could verify your experiment performing it with the same equipment and the same chemical.
- Any computer software should be identified by name, manufacturer, version and source.

RESULTS

- Sometimes the *Results and Discussion* sections can be combined into one section, but it is advisable that young scientist should keep them separated until their writing skills have improved.
- The "Results" section is also narrative just like the "Methods" section.
    - Some results are better presented in tables, graphs and figures.
    - They should be properly labelled and placed at the end of the article.
    - You can then refer to them as in the narrative as "pH changes during the fermentation process can be found in Table 1"

Important points of the results section:

- Significant outcomes.
  - You should present the relevant results that will be discussed in the next section.
  - The results should include the ones that prove or disprove your hypothesis/objectives.

For example, your experiment involves a chemical reaction that produces some amount of a specific product.

- You will get the product by filtration and determine the mass by weighing the filter paper with the product and then subtracting off the mass of the filter paper.
- The final mass of the product is important and should be in the results section. The mass of the filter paper is irrelevant.

Reference to Tables, graphs and Figures.

- Tables should be numbered consecutively and title placed above. Graphs and figures (both referred to as Figures) should be numbered consecutively below the Figures, but separate from Table numbering.
- Each Figure should have a caption briefly describing it.

DISCUSSION

- This is the most important aspect of the article. This is where you interpret and explain your results.
  - Was your hypothesis/objective/question valid?
  - Why or why not?
- Here you are trying to convince the reader of your position. Remember that even the most carefully planned experiments designed by the most experienced scientists rarely go as intended.
- The unexpected is part of the excitement of science.
  - If and when you obtain results other than expected, you must explain why.
  - YOUR READERS ARE MORE CONCERNED WITH HOW YOU EXPLAIN YOUR RESULTS THAN YOUR ACTUAL RESULTS!
- You should explain any possible errors without playing the blame game.
  - If you carried out a measurement, indicate how it was done and how it could affect your result.

Some examples will suffice here:

- Suppose you carried out an experiment to compare the growth and survival of your isolates in acidic pH.
  - Viable counts were determined, but you realised that there was no standardisation of the inocula.
- Suppose you carried out a filtration and then collect and weighed the solid, but observed that your results were way off.
  - You suddenly remembered that you weighed the filter paper after 5 minutes instead of waiting for 2 hrs.
- In the examples, you clearly identified possible sources of error, but you should go further to explain how the error could affect your results.

In the 2nd example, the drying time was insufficient and therefore the filter paper contained additional water making the measured mass to be very high.

Important points for discussion:

- Interpretation of your results.
  - What do your results mean? Explain how they are relate to the initial objectives/hypothesis
- Validity of hypothesis.
  - Is your hypothesis correct?
  - Why or why not?
- Sources of error.
  - Do not just state the error, explain it and rationalise it. Describe how the error relates to that hypothesis/question.

CONCLUSION

- You may come across some journal articles that do not include this section.
  - However, it is advisable that your article should have a conclusion.
- In addition to restating the main outcomes of your experiment, you should mention the broader implications of your work.
  - How do your results contribute to scientific knowledge?
  - By providing answer to a particular question, does your work raise more questions (this is usually the case)?
  - Do your results suggest any future experiments?

REFERENCES

- References to the research findings of others are important component of any research paper.
  - The usual style is to summarize the findings in your own words, and cite the source.
  - As a rule, direct quotation and footnoting are not practised in scientific writing.

PLAGIARISM

- This is representation of the work of others as being your work.
- Paraphrasing words too closely may also be construed as plagiarism in some circumstances, so ensure adequate referencing of all information used from other sources.

CONCLUDING NOTES

- Since journals articles are mostly written in the English Language, your work should conform to the rules and conventions of the language.
  - Proper spelling and grammar are required.
- Write clearly and concisely
- Precise word use is critical
  - e.g. Scientific terminology carries specific meaning.
- Do not use colloquial speech or phrases.
- Do not use contractions

- Use of abbreviations is not encouraged in the text, but some scientific journals allow this if the abbreviation is written fully the first time it is mentioned in the paper eg. Lactic acid bacteria (LAB), Polymerase Chain Reaction (PCR) etc.
- Use past tense throughout the paper (including the introduction section) when referring to the actual work you did and the work of others that you may cite.
- Proofread your paper before final printing.
    - It is often good to have non-scientists to help you in proofreading.
    - They often notice things a scientist will take for granted and overlook.