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Lab Reports: A Concise Guide for Non-Native English Speakers

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College students in the non-English-speaking world have to overcome formidable barriers in reading and writing when their medium of instruction is English. One particular problem faced by science majors is the writing of lab reports, a demanding task that might not be effectively supported by the standard guides and manuals available. This paper presents a new, very basic, no-frills guide aimed specifically at students in countries where English, although a second language, is also the language of instruction. The purpose of the guide is to provide an explicit structure to assist the user in presenting and communicating information in a clear and logical manner.

College students in the sciences are usually required to write laboratory reports as part of any practical course they may take in their program of study, whether in the life sciences, physical sciences, or social sciences. The importance of this ubiquitous writing assignment cannot be underestimated. Not only does it allow the students to organize and present their lab work in a standard, coherent framework, but it also forms the basis for future scientific writing in a format instantly recognizable by and acceptable to other scientists across the globe.

Mastery of the required form and content of the lab report is therefore a critical skill for nearly all science students, and it is acquired gradually as students move from lab course to lab course throughout their career. Additionally, senior students may have the opportunity to carry out original research or be involved in assisting faculty research. In either case, experience and expertise in scientific writing (i.e., lab reports) would be invaluable for their projects. While other types of scientific writing (e.g., science notebooks and persuasive articles) may also be encouraged, the lab report endures as the principal end-product of practical science teaching in most countries.

Teaching students to write according to the requirements of scientific reporting is not always an easy task (Schulte, 2003). Instruction in writing lab reports is usually provided in varying degrees of expertness by lab instructors and teaching assistants. In addition, students are referred to supplementary guides and manuals. These range from highly respected tomes such as the *Publication Manual of the American Psychological Association* (American Psychological Association, 2009) to a motley collection of more concise guides freely available on the Internet (e.g., Bates College, 2002; UniLearning, 2000).

These guides invariably describe the IMRAD (introduction, methods, results, and discussion) structure, giving an account of each section in some detail, explaining the why and wherefore of the structure (e.g., the funnel shape of the introduction), and sometimes providing examples of the type of information that needs to be included or omitted. Many guides suggest questions the writer should be asking in each section (e.g., "What background information exists on the subject?"). Instructions on appropriate style and language usage (e.g., tense, voice) may also be included. In general, the salutary aim appears to be not only to instruct the aspiring writer in the mere mechanics of report writing, but to also promote higher-level thinking and reflection.

Problems for Non-Native English Speakers

However, while these guides are more than satisfactory for the needs of the average English-speaking science student (although anecdotal evidence suggests that they are much less referred to than brief, informal handouts from lab instructors), it is not often noted that they are relatively impenetrable to students across the world for whom English is a second language.

These students often live in post-colonial countries where English is the medium of education, usually at secondary and tertiary level. As Probyn (2006) described the situation in many schools in South Africa, the students' first language, or "home" language, is used for all communication outside the classroom, and sometimes even for discussion within the class, especially if the lecturer shares the same language. Thus, while the students are functionally fluent in the English used within the classroom, they tend not to use English in any other natural context of their lives, and it remains very much a foreign language. For most, then, not only do they have the ordinary challenge of learning their subject matter, but they also have to do so in spite of formidable linguistic barriers (Probyn, 2006). Focusing on the latter leaves less cognitive processing for achieving the former.

It should be understood that students in these countries are as bright, as motivated and as hard working as their counterparts in the English-speaking world. They have similar aspirations, the same need to do well in their coursework and the same need to develop their skills in scientific writing. But unlike most of their English-speaking colleagues, they face a

number of additional hurdles to reach their goals. From primary and secondary school onwards, they may have been struggling with poor facilities and under-equipped classrooms and labs. At college level, it is likely that they have few textbooks and meager, outdated library resources, as well as limited facilities for accessing online material (Bunoti, 2011). To top it all, they have to study (read, write, achieve) in a foreign language.

Writing skills in general tend to be poor in these situations. For example, Fatima (2012) highlighted problems in writing faced by college students in Pakistan, while those faced by Arab post-graduate students in Malaysia were described by Al-Khasawneh (2010). Scientific writing such as the lab report is often found to be a particularly difficult assignment. For example, McLaren and Webber (2009) noted the poor quality of scientific writing of undergraduate science majors in Jamaica. In fact, Cameron et al. (2009) estimated that difficulties in scientific writing faced by second-language English speakers are "four or five times as much" (p. 510) as those faced by native English speakers. Apart from linguistic barriers, there is the problem of few prior opportunities for scientific writing. Scarce college resources frequently do not allow for lab classes until senior-undergraduate or even postgraduate level, when students are suddenly faced with the requirement to write a lab report. Novice researchers can have particular difficulties in scientific writing (Shah, Shah, & Pietrobon, 2009), and indeed, prior experience has been highlighted as one of the most important factors for successful report writing (Jerde & Taper, 2004).

Thus, science students in non-English-speaking countries who are studying in English can face enormous difficulties in developing the skills critical for scientific writing, and as such, are handicapped in achieving their immediate goals of academic progress as well as their future career development as scientists.

A New Guide for Writing Lab Reports

The purpose of this paper is to present a practical guide to the basics of lab report writing, aimed at undergraduate (or inexperienced postgraduate) students in non-English-speaking countries, where English is the medium of instruction. It could even be helpful for English-speaking students who need extra assistance in writing their lab reports.

Writing a good lab report requires mastery of both its structure and its content. The proposed guide (see Appendix) offers support mainly in structural aspects. This means that cognitive resources can be diverted from struggling with nuts-and-bolts-level information (the basic format of the report, what must be included in each section) to focusing on the content of the report (higher-level understanding and reflection). It might be noted that several aspects of an explicit structure (e.g., sequential steps of the introduction) could be helpful in prompting the logical organization of thoughts and arguments as well.

The proposed guide takes a very basic, no frills approach and gives the student clear directions at every step, along with illustrative examples. This reflects the call for instructors to make their expectations for student writing in the sciences "explicit and accessible" (Cabral & Tavares, 2002, Implications of the Study section, para. 3). It was felt that, in the beginning, students would benefit more from direct instructions (e.g., "State two reasons why your study is important") than from a description of the funnel-shaped structure of the Introduction. Further, examples are largely in the form of sentence stems (e.g., "These findings suggest strongly that . . .") that could also act as prompts for writing. This reflects Webb's (2009) use of writing frames to scaffold the scientific arguments of students in South Africa. The examples also provide models of appropriate language and type of usage required.

A pilot implementation of this guide at the University of Dodoma, Tanzania, yielded positive feedback from undergraduate users carrying out a lab assignment on Plant Ecology. Each student was given a copy of the guide to refer to and, after handing in the completed assignment, was asked to fill out a feedback form.

All 25 students who completed the feedback form seemed to have actually referred to the guide, which was an encouraging sign. Ratings on a 5-point "helpfulness" scale (ranging from 1, *not at all helpful*, to 5, *very helpful*) yielded means of 4.7 and above for each sub-section of the guide as well as for the guide overall.

In addition, about half of the students (12) said that they had referred to another lab report guide, either for writing this assignment or in the past. Of these, a majority (eight students, or 67%) said that the new guide was better, while three (25%) said that both guides were similar. Only one student preferred the other guide. Further written comments from the students indicated reasons for liking the new guide. These included "better and more easy to use," plus that "it directs specifically what should appear in each section."

It would therefore seem that the present guide has some measure of credibility and acceptability in at least one sample of its target user group – science undergraduates whose first language is not English.

Description of the Guide

While there is a complete version of the guide in the Appendix, what follows here is a brief description of each section, along with its rationale and practical

application. Interested teachers might find this helpful when using the guide, and also when finding it necessary to make modifications for their discipline and/or course requirements.

Abstract. Here the guide instructs students how to summarize the entire study in six sentences, leading to a terse condensation that covers the study question, methodology, key results and implications.

Introduction. The Introduction, of course, provides the context or background story to the study. It is often described as ideally following a funnel shape, beginning with the broad topic of study, and narrowing down, via relevant research, to the hypotheses of the experiment or study being carried out.

The guide takes students through the general-to-specific structure in six paragraphs, with each successive paragraph taking another step of increasing specificity. For example, the first paragraph deals with the general topic area, while the second takes on the sub-topic area. By paragraph 5, this has narrowed down to "your study—reasons for doing it," rounding off with paragraph 6, "your study—expected results, and why they are important." While six paragraphs with prescribed content might be considered overly simplistic or formulaic, the advantages are that it can immediately assist students in ordering their thoughts and notes into a logical progression, and perhaps even further their understanding of how their study fits in with other research and the larger underlying topic.

The student is instructed clearly at each step as to what is required. For example, in paragraph 3, "sub-topic area—research," the student is asked to "write two or three sentences" to describe each of three other relevant studies, including their important/interesting findings. Again, this might be considered formulaic, but on the other hand, it strongly encourages the student to actually locate and summarise at least three primary sources.

In addition to the direct instructions, side-by-side examples offer further inducement to write, in a "see, this is how it might be done" form of encouragement.

Methods. The Methods section describes the procedural aspects of the study. Unlike other sections of a lab report, this usually has clearly demarcated subsections (e.g., Materials), varying slightly by discipline. However, the guide again provides explicit instructions and examples for each subsection.

While six subsections are suggested, relevant ones may need to be selected by the lab instructor. For example, lab reports in Psychology might omit statistical tests, while non-field studies may not require the "study site" subsection.

In the "note to lecturers" at the end of the guide, it is suggested that further input from the teacher for the design subsection might be highly beneficial, as experience shows this to be one of the most common points of weakness in the reporting of a study. A clear understanding of the design will not only aid students in writing the Methods section, but should ideally clarify their perceptions of how the design relates to their hypotheses and how both design and hypotheses relate back to the overall question. A firm grasp of this underlying rationale would aid the eventual structural integrity of the report, with relevant connections made from the Introduction right through to the Discussion.

Results. For the Results section, the guide first presents, with little explanation, a sample table and graph, on the assumption that a careful copy of the format shown (e.g., placement of title, use of horizontal lines in table) will yield better illustrations than written instructions, especially for non-native English speakers. The guide then instructs students to describe, in a paragraph each, the important and interesting findings shown in the table and/or graph.

Discussion. From the point of view of the students, the Discussion section might be the most mystifying section of the lab report, and it often turns out to be overly focused on one or another aspect of the results of the study. The guide suggests that the Discussion be written in four paragraphs, to ensure a more even coverage of the standard content of matching results to hypotheses/expectations and noting implications, comparing with prior research, making an evaluation, and offering suggestions for future research.

The instructions also make backward links to specific paragraphs of the Introduction, to remind the students where, for example, relevant prior research has been described. These connections are intended to facilitate greater unity of thought across the report.

References. As in the Results section, it was felt that modelling the appropriate format of reference entries for a journal article, a book and an Internet report would be more immediately helpful than a verbal description of the underlying scheme.

Notes. The guide ends with two pages of notes. The first is a page of five general notes marked as important for the student. These cover a suggested order of writing (e.g., the Abstract is generally written last), plagiarism (with a brief suggestion on how to write in one's own words), the use of quotations (don't), and encouragement, when the student is ready, to deviate from the guide as well as to refer to standard publication manuals. The second page of notes is for the lecturer (as mentioned above in the description of the Methods section), and these simply suggest that many students would benefit from further support and clarification with respect to the hypotheses and design of the individual study, in turn leading to a better report overall.

Conclusion

It is clear that this basic guide is not without potential problems. In its present form, it is more

suitable for students in the biological and social sciences, although lecturers in the physical sciences could offer supplementary instructions to their students. Another potential problem is that all the students in the class could end up having very similar (although not identical) reports, down to the same number of paragraphs and sentences. However, this may be something that is quickly overcome as more assignments are completed and the students gain confidence in deviating from the original instructions.

It might also be argued that this type of guide does the students' work for the, and lowers expectations and educational standards. However, it should be clear from the points made above that the targeted population of students may just need a little extra scaffolding than more privileged students when it comes to writing formal lab reports. It could be argued that students sometimes cannot scale the ladder of success if the bottom rungs are missing, and it is this gap that the proposed guide intends to fill.

Students following the simple steps of this basic guide should be able to complete a conventional lab report assignment. This will likely be followed by a sense of achievement and increased confidence in doing the exercise successfully the next time around. Repeated occasions would then lead to familiarity and ease with the basic report structure and the most important requirements. Ideally it would also lead to a sense of dissatisfaction with the (necessary) limitations of the guide, encouraging the student to look elsewhere for supplementary information (which is where other, standard guides would come into their own) and be more receptive to their lecturers' corrections and feedback.

In conclusion, it is proposed that this guide would give students a basic toolkit to actually get started on writing their lab reports, instead of defeating them at the very beginning.

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Appendix
A Guide for Writing a Scientific Report

Writing a Scientific Report

A practical guide to the basics of scientific writing

L. Soundranayagam

What this guide is about

You have carried out a study, and collected and analysed your data. You now have to write it up for a class assignment, or maybe for publication. Either way, you will have to follow the basic 'lab report' format, with which you may already be familiar.

This format is actually the easiest way to write about your study because the structure is already clearly laid out. It makes sure that all the important parts of the study are covered. And it also makes it easy for other people to read, and to quickly locate the information they want.

The report format is explained below, section by section. Examples appear in red.

Follow the guide carefully, step by step, and very soon your report will be written and ready to go!

Abstract

Here you write a brief summary of the whole study. It is easiest to write this after the rest of the report has been completed.

You can write an abstract in six sentences:

Sentence 1: State the specific question this study investigated.

Sentence 2: State the main methodology used in the study.

Sentences 3 and 4: State the key results (the key results are the ones that directly answer the study question).

Sentences 5 and 6: State the implications of the key results.

Seasonal fluctuations in species detection were . . .
The two populations were observed over . . .
Significant recovery rates were found for . . .
These findings strongly suggest that

Introduction

Here you tell the background story to your study. Your story should move from general to specific—from the general topic area, to more specific areas that other people have researched, and then to your specific study. Overall, it should answer the question—why was your study needed?

You can write an Introduction in six paragraphs.

Paragraph 1: General topic area

Write a few sentences about the general topic area that lies behind your study. Include a few reasons to show why this topic area is interesting or important. As you write, make at least two references to other authors (of research articles or textbooks) who support what you say.

Paragraph 2: Sub-topic area

Write a few sentences about the sub-topic area that is directly relevant to your study.
Emphasize why this area is interesting or important.
Clearly describe any significant controversies or disagreements in this sub-area.

Paragraph 3: Sub-topic area—research

Describe the findings of at least three other studies in this sub-area. Write two or three sentences to describe each study, mentioning their important findings and/or anything interesting about their methodologies.

Paragraph 4: Sub-topic area—conclusions

Write two sentences summarizing the main findings from Paragraph 3. Then describe clearly why further research is needed.

The depletion of forests across the world has caused . . . This is of particular interest to biologists . . . . . . as noted by Bhatt (2011) in her review of this topic.
Range contraction of large carnivores has… This is particularly important as… However, many ecologists disagree with this finding . . .
A recent study by Andersen and Simic (2012) showed that . . . Pichler's (1998) new method of detection soon became the . . .
It is clear from these studies that . . . However, there still seems to be a gap . . .

Paragraph 5: Your study—reasons for doing it

Most studies either use a new methodology to investigate an old question, or use accepted methods to investigate a new question. In a few sentences, link your question (same or new?) and your methodology (same or new?) to the important findings/controversies of Paragraph 2, and the research in Paragraph 3.

The present study modified the methodology of Katz et al. (2005) to . . .

In this way, the study hopes to address the problem that has . . .

Paragraph 6: Your study—expected results, and why they are important

Write a few sentences about what results you are hoping to get, and what these results would contribute to the topic area.
Make sure to emphasize why your study is important.

It was expected that small mammals in forested areas would . . .

This information could be critical to the success of conservation efforts . . .

Methods

Here you describe how your study was carried out. It should be so clear that anyone else could read this section and carry out a similar procedure.

You can write this section in four or five paragraphs.

Paragraph 1: Study site (write this paragraph only if your study was a field study)

Identify the location of the study site.
Describe the study site, mentioning the physical characteristics of the site and the season(s) during which the study was carried out. Describe the main vegetation and animal populations, if relevant.

Observations were made at Lake Gyr, located at . . .

Elevations along the ridge range from . . .

The area is dominated by evergreen forest . . .

Paragraph 2: Organisms studied

Specify the animals or plants under investigation in the study. If relevant, mention the age or sex of the organism studied.

Only pregnant or lactating female rats were included in . . .

Paragraph 3: Design

State the number of conditions (or groups) in your study, which you are using to answer your question or test your hypothesis.
State the number of samples taken or observations made in each condition (or group).

Six experimental plots of 2 ha each, along with two control plots of . . .

Traps were deployed for two consecutive days in each . . .

Paragraph 4: Materials

Describe the materials used in the study. Write at least one sentence each to identify and describe any unusual equipment used.

A sieve with a diameter of 26cm and mesh of 2mm was used . . .

Two EZTrail 643XL remote cameras were . . .

Paragraph 5: Procedure

Describe in some detail the procedure you followed. Do this step by step, in the same order the procedure was actually carried out. It should be clear when and how the observations were made or the samples taken.

Direct sightings were recorded from 6am to 7pm each day, with…

The sample was then stored at 18C for 6 hours to ensure that . . .

Paragraph 6: Statistical tests

Describe how the data were treated.
State the statistical tests that were used to process and analyze the data.

> Specimens that weighed less than 20g were scored 1, while . . .
>
> Differences between the groups were tested by a one-way ANOVA . . .

Results

Here you present the main results of your analyses (do not show any raw data).

Show the results in clearly labeled tables and graphs. Follow the format of the examples below.

Table 1. Mean number of direct sightings of target species in each grid plot

Target species	Plot A	Plot B
Leopard	2	0
Sloth bear	4	7
Jungle Cat	9	3
Common palm civet	0	1
Ruddy mongoose	6	2
Total	21	13

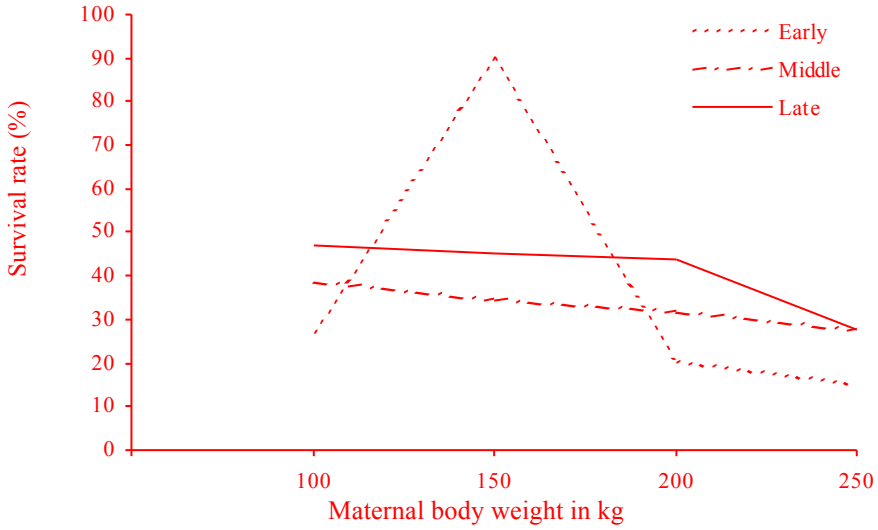

Figure 2. Percentage of early-, middle-, and late-born seal pups surviving as a function of maternal body weight

Write one paragraph for each table and graph to describe anything interesting or important you see in the results.

> Figure 5 shows that fish exposed to the highest level of NaCl had the lowest body mass ($F2, 9 = 10.8, p < 0.01$) . . .

Discussion

Here you reflect on the results, make interpretations and draw conclusions.

You can write the Discussion in four paragraphs.

Paragraph 1:

What do the results seem to say? Do they match your expectations (as mentioned in the Introduction, Paragraph 6)? What are the implications for the topic area (as mentioned in the Introduction, Paragraph 6)?

The clear relationship between day-length and breeding supports the . . . These results confirm the importance of maintaining forested . . .

Paragraph 2:

Are there any other implications of the data? Do the results agree or disagree with other research in this area (as mentioned in the Introduction, Paragraph 3)?

Further, the observed response lag suggests that . . . This agrees with the findings of Varga and Bishop (2006) . . .

Paragraph 3:

Make an honest evaluation of the study. Did anything go wrong? Did anything unexpected happen? If you were to run the study again, what improvements would you make?

One unexpected finding was that . . . This would need to be monitored in future . . .

Paragraph 4:

Based on the findings in this study, can you suggest any further questions that would be interesting to explore?

This would be a useful tool for further exploration of the . . .

References

Here you list all journal articles, books, websites or other materials you have referred to in this report. Put the list in alphabetical order.

Use the following format for each reference in the list:

Journal article:
Pedersen, L., & Leroy, K. (2002). The impact of habitat fragmentation on songbird diversity in East Africa. *International Journal of Ecology, 12*, 25-32.

Book:
Harris, L. C. (2003). *Animal physiology*. New York, NY: Wiley & Sons.

Internet report:
Angelo, W., & Crieff, J. (2012, June 6). *Species survival*. Retrieved from http://biology.conservation.farnell.edu/301/resource/560/01/

Important!

1. Write the sections in any order that you like. It is often easiest to write the Methods and Results sections first, followed by the Introduction and Discussion, and lastly the Abstract and the Reference sections.

2. The entire report must be written in your own words. Resist the temptation to copy someone else's words, whether from printed material or the Internet--this is called plagiarism, and is unacceptable in the report that you are writing.

Sometimes it can be difficult to write in your own words. The best way to do this is to read the source material very carefully, then close the book or look away, and write it out in your own words.

3. Do not use quotations. These are nearly always unnecessary. Instead, re-write the original material in your own words.

4. As you become more familiar with the format set out in this guide, and with reading other journal articles, you will feel comfortable deviating from this basic structure as needed. For instance, you can vary the number of paragraphs in the Introduction to suit the amount of research in the area and the type of topic you are studying.

5. For more information, refer to a publication manual or the publication guidelines suggested by your lecturer or journal editor.

Note to Lecturers

While this basic guide is intended as a stand-alone manual that students should be able to refer to without requiring additional help, it is suggested that certain sections might benefit from extra clarification with regard to the specific experiment or study being carried out.

Introduction, Paragraph 6: Students might need a little extra help to be completely sure of their hypotheses, and how these relate to the overall question.

Methods, Paragraph 3: Students may need help to understand/remember what exactly the design of the study was, including the number of conditions. They may also need support in understanding how the design relates back to their hypotheses.

Clarity with regard to hypotheses and design would be particularly helpful to ensure the structural integration of the whole report, from the Introduction right through to the Discussion.