

# **Assignment Reports in Computer Science: A Style Guide, Grader's Version**

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An assignment report for a course in the Queen's University School of Computing should be written in the general format and tone of an article in a peer-reviewed journal. There are at least hundreds of style guides that provide extensive and detailed information; a useful technical guide is published by the Institute of Electrical and Electronics Engineers (IEEE) and a widely regarded general guide is the *Chicago Manual of Style*.

In general, the report should be written to clearly communicate the methods and findings of the assignment to the person who is grading the report. The reader is probably a teaching assistant who needs to evaluate many students in a limited time. Anything that detracts from clarity – such as too much information, too little information, poor report structure, or poor English usage – can be reasonably expected to result in a lower grade.

Clear communication is an art that requires thinking and practice to do well. An effective report demonstrates that the work was done and, also, that the author understands the concepts of the assignment. Most university students are adept at describing their work but are less practiced at communicating their conceptual understanding. This guide will provide a structure that helps to communicate that the ideas in the assignment have been understood.

The structure of this guide is intended to help a student to be clear and concise. First, the format of a report will be described in general. Next, the relevant sections will be discussed in moderate detail. Third, citations and references will be briefly explored with the understanding that they are not usually important in a computer-science report but are crucial in a peer-reviewed submission. The guide ends with general comments.

An astute student will have already observed that this guide is written using journalism's "inverted pyramid" and in the passive voice. The inverted pyramid organizes material, such as a paragraph, by placing the most important or the conclusive information first; this way, the reader has a conceptual framework for understanding what follows and is not trying to unravel a mystery novel's knotty thread. The passive voice removes the author from sentences and, as plainly as possible, states the material. There is current debate about whether to use the active or passive voice in a report, so a student should ask a teaching assistant about any preferences that they or the instructor might have. (I prefer to write in the first person, active voice, but I recommend third-person passive voice for an assignment or a style guide.)

An important assumption about the purpose and readership of the report is about the nature of the work. In computer science, a typical assignment either explores a scientific question or establishes that requirements have been met. This style guide assumes the former, that there is at least one scientific question in the assignment. Here, a “scientific question” is one that is testable and falsifiable. That is, the report is assumed to be about some test that is conducted where the test can have true outcomes or false outcomes. Questions that are not scientific, but which might be reasonable topics of an assignment, include theorems to be proved or requirements to be satisfied. This document is not intended to be a guide for every useful assignment format; it addresses only the scientific style of report.

An important topic that this guide only lightly describes is how to reference the work of others. Citations and references are crucial to a good scientific article but, in computer science assignments, are seldom needed. This guide omits detailed discussion not because references are unimportant but because they are not expected to be directly relevant to most assignment reports.

## **1. Structure of the Report**

An assignment report has the structure of a typical scientific article: a preamble, an introduction, a description of the methods, the main results, a discussion of the results, and references. Each of these topics will be described in detail after being described generally in this section.

The preamble material is the title, author, and an abstract of the report. Although this material appears first in the report, successful students often write this material last; the abstract is clearest when all of the body of the work is complete.

The introduction, for an assignment report, is usually short and factual. The main idea to communicate is the purpose of the assignment, which is the scientific question. This might not be explicitly stated, so a student may need to think and draft multiple attempts before producing a clear question. The introduction will also describe the necessary theory and conceptual setting of the assignment.

The methods, in an article as well as in a report, describe the work performed in a way that supports scientific replication. The methods are really the heart of the report. The reader needs to know what was done and in what order. Keeping in mind the reader – who is most probably a grader – a student needs to describe the ideas behind the code so that the reader could reproduce the results from the report and the reference material.

The results are a factual statement of the findings, largely devoid of commentary. In an assignment report, these are often data that are presented as tables and/or as figures. The

tables and figures must have captions that are concise and “stand alone”. A student should expect that a reader might glance at the abstract and turn immediately to the results, so the figures and tables should not require extensive reading of the methods section to understand. Common mistakes to avoid are providing methodological descriptions – such as describing statistical tests – or interpreting the results, which is the purpose of the discussion.

The discussion is where concepts are communicated and conclusions are drawn. In an article, this section and the introduction often have extensive citation to the works of others; in an assignment report, citations might be minimal or absent. The discussion is where themes are described, inconsistencies or paradoxes are observed, and the scientific question for the assignment is directly addressed. Common mistakes to avoid are presenting new results to the reader and failing to summarize the findings.

## **2. Structure of the Preamble**

The title page should include:

- Header: Student number on the left, page number on the right
- Title: Descriptive and specific, not to exceed 10 words
- Abstract: not to exceed 300 words (or another stated limit) and should include:
  - One sentence on the objective or purpose of the assignment
  - One sentence on the methods
  - The main results of the assignment
  - The main conclusions or interpretations of the results

The abstract must be short. Most students find that, after the hypothesis has been stated, the results are known, and the conclusions are drawn, it is much easier to meet the word limit than it is when writing the abstract first.

A shorter abstract is acceptable and might be preferable. Many conferences and journals have even tighter limits, such as 150 words. Many companies prefer that a presentation begin with an executive summary. A student can approach an assignment report as an opportunity to begin practicing for communication in the rest of their professional career.

### **3. Structure of the Introduction**

The introduction of an assignment report states the motivation of the assignment and describes the context of the study. This is usually in three parts, often in three paragraphs. The introduction is the first place where the reader can appreciate a student's understanding of the concepts of the assignment.

The first part of the introduction is the purpose of the study. A student should state the scientific question and describe, in general terms, how the question was tested. Using a sentence such as "The objective was ..." or "The scientific question was ..." may help to structure this part. A common mistake is to describe the educational purpose rather than the scientific purpose. For example, if the assignment states that a binary search is to be implemented to determine whether a given integer is in a given set, the purpose is not "to learn how to search a set" or even "to use binary search on a set"; the purpose might be better stated as "to determine whether a binary search requires fewer comparisons than a linear search for the data sets provided in this assignment".

The second part of the introduction describes the background of the assignment. Keeping in mind that the reader is the grader of the assignment, this part should clearly and briefly describe the concepts surrounding the assignment. This part may be long and should cite literature that is relevant to understanding the report. If needed, a description of specialized methods or data sources can be given; for an assignment this might be a single crisp sentence.

The third part states the scientific question and how the question was tested. The question is distinct from the purpose that was stated in the first part of the introduction. For the example of a binary search, the purpose might be to determine whether an implementation of binary search was more efficient; the scientific question might refer to counting the comparisons that were made in code. The testable predictions might be applied to a specified number of data sets, some of which have various relevant properties.

In summary, the introduction of an assignment report will typically vary in size from three sentences to three paragraphs, depending on the complexity of the assignment.

### **4. Structure of the Methods**

The methods of an assignment report will typically describe the algorithm used to solve the problem of the assignment, the testing process, and how the tests were evaluated. The algorithm can be described generally because the accompanying code should have internal documentation that more fully describes how the code works.

The testing process establishes the scientific reproducibility of the assignment report. It should be sufficiently clear and detailed that another student can, from the description, completely reproduce the results using the accompanying code. If special parameters or settings are needed, they should be documented here as well as in the code. Examples are how to invoke the code and, if needed, how to interact with the code to produce the results of the assignment.

As needed, the evaluation process should be described. For an assignment that has fulfillment of requirements as an important component, the quantitative assessment methods should be described. If multiple data sets are used, or if randomization is part of the solution, then these must be described in sufficient detail for scientific reproducibility. An example for binary search is that the reported number of integer comparisons would be compared to a theoretical upper bound; another example is statistical comparison of mean values, for which the details of the parameters of a t-test must be provided.

The methods section may vary in length from a single paragraph to multiple pages, depending on the complexity of the assignment.

## **5. Structure of the Results**

The results of an assignment problem are usually values that are presented in tables and/or figures. As mentioned in the general guide, The tables and figures must have captions that are concise and describe the data without much need to refer to the methods.

Numerical results should be presented with only as many significant digits as make sense. If too many digits are presented, then the reader might conclude that the student has an insufficient grasp of the problem and the context. For example, if numbers are in tens of millimeters then reporting more than one or two decimals is likely inappropriate; if numbers are angles in tens of degrees, then more than one decimal place might not be relevant.

The results should not be discussed or commented on beyond minimum needs. Common mistakes are to draw conclusions too early and to include new methods in the results. For example in an assignment with statistical results, the tests should be described in methods and the  $p$  values should be stated in the results; asserting the statistical significance is a debatable practice that should be avoided, so that bad habits are not formed.

The style of a table has the caption above the data. Each column and each row should have a terse descriptive label. The style of a figure has the caption below the data. A graph should have clearly labeled axes and, if more than one data source is presented, there should be a terse legend or a terse description in the caption. Common mistakes are to have illegibly

small fonts in a graph, to have poorly labeled axes, and to have blurry screen captures instead of crisply rendered original plots.

An exception to these guidelines is the highlighting of important results. It is common to use a bold-face font for significant or major results that will be assessed in the discussion. Highlighting a few important results will help the reader to better understand the results when they are discussed.

The results section may vary in length from a one paragraph plus data to multiple pages, depending on the complexity of the assignment.

## **6. Structure of the Discussion**

The discussion is where results are assessed and conclusions are drawn. This is where the scientific question is evaluated, where the results are put in context, and where a student can demonstrate conceptual understanding of the educational purpose of the assignment. It is common to have three parts to the discussion: analysis, interpretation, and conclusions.

The analysis of the results is a statement of the scientific findings. If there are clear trends, or clear counter-examples, these should be stated in the analysis. If there are statistical comparisons, the significance of the results can be assessed. This part may be relatively short in an assignment report because the results are usually uncontroversial.

The interpretation of the results is where a student can demonstrate conceptual mastery of the subject matter. Trends, similarities, differences, and ambiguities can be described in the appropriate context. This is where the scientific question should be resolved by the results.

The interpretation may, depending on the assignment, also include a discussion of error and the limitations of the methods. Common mistakes include: attributing results to human error, which implies that the student was incompetent; comparison of results to an impossibly high or low standard; and, if relevant, not understanding the limitations inherent to any empirical study. Together, the analysis and interpretation may vary in length from one paragraph to multiple pages, depending on the complexity of the assignment.

The conclusions of an assignment report are usually simple and straightforward. If the scientific question was supported or if a counter-example was found, few words are needed. One or two sentences often suffice to summarize the factual findings.

## **7. References**

In an undergraduate assignment, references to external work vary from few in number to extensive. As a general rule, primary peer-reviewed work should be preferred. Review

articles, blog posts, encyclopedic articles, or web sites are not authoritative but a student can use these sources to inform the reader about what concepts were used in understanding and performing the work in the assignment. An important exception is when referring to course material, such as notes or data sets, which must be cited and are usually in electronic form.

For many science professionals, peer-reviewed articles are their primary intellectual property so it is essential that they be cited appropriately. There are many useful citation and reference styles; a student should select one style and use only that style. If an assignment does not specify the reference style, then the Vancouver style should be used because it is concise and widely recognized.

## **8. General Advice**

Writing is an art that takes practice to do well. An assignment report might need multiple drafts so a reasonable time should be allotted for writing the report. Many students find it useful to use a “top-down” approach in which they write short description of each paragraph before filling in the details.

Many science professionals also write reports “inside out”. It is common to start with the hypothesis, then write the methods and the results. After the results are known, the discussion can be composed. After most of the report is written, the material is clearly prescribed and can be introduced to the intended reader.

Many professionals will not write the abstract until the rest of the report is complete and edited. It can be quite difficult to describe an entire assignment in only a few words, but effective communication often requires brevity so this is a useful skill to acquire and polish.

For people who do not have regular practice in technical writing, common errors are using too many words and using casual language in a technical context. There are many style guides – often subtly humorous – that can help a student to avoid common mistakes such as writing “based on the fact that” where “because” suffices, or “needless to say” when the phrase and what follows can be omitted entirely. At Queen’s University, Professor Chris Eckert in the Department of Biology has a useful list of expressions to avoid. There are also entire books on the subject that an interested student can easily find.

When in doubt, it may be useful to simply ask the audience. In the case of an assignment report, a teaching assistant is likely to be your most helpful guide.

# *Sample Report Style and Data Formats*

*Student Number: 01010001*

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## **A REPORT TITLE THAT HAS FEWER THAN TEN WORDS**

### *ABSTRACT*

**PURPOSE:** Compare the computational efficiency of binary search to linear search on small sorted data sets of integers.

**METHODS:** The two search algorithms were implemented and tested on the data sets provided by the instructor. The maximum numbers of integer comparisons were accumulated and tabulated. The most efficient algorithm was determined to be the algorithm that used the fewest comparisons.

**RESULTS:** On data sets with fewer than four entries, there was no clear efficiency decision. As the size of the data sets increased, the binary search algorithm was more efficient.

**CONCLUSIONS:** The implemented algorithms asymptotically approached the theoretical number of integer comparisons as the size of the data increased. For large data sets, the binary search algorithm is recommended in applications requiring computational efficiency.

Word Count: 123

### *INTRODUCTION*

The first paragraph states the scientific purpose or objective, often as a single sentence.

The second part, in one or more paragraphs, describes the background. Citations are preferably made using the Uniform Requirements of the International Committee of Medical Journal Editors, which is more widely known as the Vancouver [?] style. This part is often written after Methods and Results are finished.

The third part states the scientific question and how the question was tested. This testable hypothesis is not the same as the scientific objective.

### *METHODS*

Begin by describing the algorithm used to solve the problem of the assignment, such as how a binary search is performed.

The testing process needs to be described so that the results can be scientific reproduced. special parameters or settings should be documented here as well as in the code.

The evaluation process should be described. If statistical tests are appropriate for the course and the assignments, then they must be described here.

## RESULTS

The tables and figures must have captions that are concise and describe the data without much need to refer to the methods. Numerical results should be presented with only as many significant digits as make sense.

Table 1: caption is above the data

Size	Binary	Linear
4	~	~
16	~	~

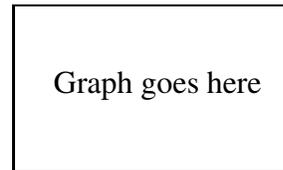


Figure 1: caption is below the data

## DISCUSSION

The first part is a statement of the scientific findings.

The second part is an interpretation of the results, where a student can demonstrate conceptual mastery of the subject matter. This may take one paragraph or require multiple pages. The body of the report should follow the guidelines of the most recent IEEE Editorial Style Manual [?].

The conclusions of an assignment report are usually simple and straightforward.

## REFERENCES