How to Write a Winning Scientific Paper

El autor ha tenido que juzgar artículos para otorgarles el premio a los mejores del año. Para ello ha tenido que revisar muchos, y ha sido capaz de encontrar cuestiones generales que, si bien no aseguran un triunfo, por lo menos si ayudan a evitar el fracaso.

Selecciona los elementos que en opinión del autor son los esenciales para obtener un texto de buena calidad. Una descripción exhaustiva de estas cuestiones se puede encontrar en el libro de Robert A. Day (How to Write and Publish a Scientific Paper) citado en la bibliografía comentada del curso. Ahí se le dedica un capítulo a todos y cada uno de los elementos, no sólo de la rpeparación del manuscrito, sino del proceso de publicación (ej. "Cahpter 17 "The review process: how to deal with editors").

Por la brevedad del artículo merece la pena leerlo, la consulta del libro de Day es también muy recomendable, pero obviamente no se puede poner como material del curso (fotocopiado) un texto completo de 200 pgs. Pero creo que sería muy bueno para todos hojearlo y saber de su existencia, ya que el día que realmente se tienen problemas no está uno para buscar bibliografía.

Se incluye aquí también un editorial del Optical Engineering en el que se comente la necesidad de referenciar (y referenciar bien) a los autores que han contribuido al desarrollo del campo científico al que hacemos una contribución con muestro original. A mi me parece que es incluso demasiado débil en la defensa de la referencia como una obligación moral.

J. Sevilla 12 de diciembre de 2003

How To Write A Winning Scientific Paper

A Judge's Perspective

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When presented with hundreds of technically excellent research papers, how does one choose the twenty "best"? This is the dilemma faced by a small number of hard working judges for the IEEE EMBS/Whitaker Foundation Student Paper Competition each year.

Entries to the Student Paper Competition (SPC) are in the same format as all other papers submitted to the IEEE EMBS Conference. When embarking on writing a paper for the SPC, you should first obtain an Author's Kit. You should also request the special instructions for the SPC.

Each SPC paper is reviewed by at least five judges who score it in three major categories: *Structure of the Report* (30 points), *Composition* (30 points), and *Technical Merit* (40 points), for a maximum possible score of 100 points. The *structure of the report* refers to the proper use of the standard sections in a scientific paper. *Composition* refers to proper use of grammar, spelling, punctuation, sentence and paragraph structure, and tense. It also is concerned with the ease with which the message can be read and understood. *Technical Merit* takes into account the completeness of the work and the substantiation of the results.

It is essential to obtain an Author's Kit and to closely follow the Instructions for Authors. Since the publication will be directly photographed from what is submitted, it is crucial that the paper strictly adhere to type sizes and type faces, margin sizes, and the layout of the title, authors' names and institutions. In a short paper, the subject should be well defined and on a narrow topic; there is not enough space to do justice to a broad topic. Regardless of length limitations, in a good quality paper all parts of the paper are concise.

Performing good science is only part of the role of a scientist. An equally important part is telling people about it. There are several considerations that should be kept in mind when you are writing about your scientific work. The most important of these is to remember your audience. Your own research work is so familiar to you that you will tend to make some very common mistakes. For one, in the laboratory you probably use jargon terms to describe your work. *Jargon has no place in a scientific paper.* Another common error is to assume that your audience knows all of the details of past work in your particular topic. A well defined scientific paper format is needed to ensure the clarity of your report.

Engineering literature often contains papers that are concerned with design rather than pure science. The emphasis in such a paper is the design itself. Since the design must be tested to demonstrate its efficacy, the same layout that is used for a scientific paper also applies to a design paper.

Sections of a Paper

The layout of a scientific paper is fairly standard and is divided into five distinct sections: Abstract, Introduction, Materials and Methods, Results, and Discussion. While specific variations to this formula may exist, the general layout is commonly found throughout all branches of science and engineering.

The paper begins with an Abstract. As the name implies, the entire paper is summarized, or abstracted, in one paragraph. Typically, the important points of each section of the paper are contained in two to three sentences. The length of the Abstract is often specified in the Instructions to Authors of a particular publication.

The Introduction is the section in which the background and the significance of the topic are described. The Introduction is the section that provides enough information for the audience to place the current work in perspective. The Introduction describes the problem that is being addressed by the paper and then discusses pertinent prior work upon which the current work is based. The majority of the references to other work should be made in this section.

The section following the Introduction is usually called Materials and Methods. This section contains a complete description of the procedures used to perform the current study. The description must have sufficient detail so that others could duplicate the experiments. If some of the methods are commonly used and have been reported elsewhere, their descriptions can be minimized with appropriate references. It is sometimes useful, however, for the reader to have pertinent details of the referenced methods repeated in the current paper. Major materials and equipment should be described with a model number and manufacturer's name. Also place the location of the manufacturer in parentheses (city and state or country).

The Results section follows Materials and Methods. Its sole purpose is to report the results of the studies described in the previous section. A common mistake is to discuss the results in the Results section. This is not an appropriate place for such discussion; rather, it is just a list of results and is often very short. It is also unnecessary to describe how the results were obtained since this should have been covered in the Materials and Methods section. The Results section can reference *tables* and *figures* as alternate ways of reporting the data. Very often however, tables are overused. Besides taking up a lot of space, they can contain more information than is necessary. It is usually unnecessary to list the individual results from each subject in a study, when appropriate application of statistics will generalize the results from all subjects and provide a more intelligible synopsis. Figures must be legible and not cluttered with excess detail. Lettering must be proportional in size to the graphics, and be large enough to read comfortably.

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The contents of the Discussion section are less well defined than the other sections. This is the author's forum to discuss whatever is pertinent to the work described in the paper. There are certain things, however, that every Discussion section should have. It is appropriate to start this section with a short summary of what was shown in the experiment. Since every experiment contains some experimental errors, the sources and implications of these errors should be thoroughly discussed in this section.

References to other work that are made in this section are generally for the purpose of examining experimental error. These references need not be to work done on the same topic but can be papers on associated topics that use similar experimental techniques. The end of the Discussion section should close the paper and leave the reader with the impression that the story is complete.

The Reference section is also an important part of the paper. One of the most common errors in paper writing is to not use the appropriate reference format. All citations included in this section should have been referenced in the paper. Only pertinent references are necessary, particularly in a short paper. The order of references differs between publications, so be sure to use the appropriate order as described in the Instructions for Authors.

Statistics

Most often, the best way to report results is with the proper use of statistics. Appropriate statistical measures serve to generalize the set of individual data points based on their probability distribution. When culminated in a probability, or *p level of significance*, the reader is given the likelihood that the data show what was expected. A very common mistake in reporting results is to leave the statistics at an intermediate level. For instance, a *Pearson's r correlation coefficient* is often used to tell the goodness of fit between data and a regression or between two sets of data. The value of r can vary from 0 to 1, with 1 representing perfect correlation. However, how does one decide what is a good value of r? The number of data points effects the value of r.

Expressing correlation as a probability corrects for the number of data points, stating the probability that the two data sets are uncorrelated. It is at this point that an acceptable probability is determined. Most often, acceptable levels of significance are defined by the field in which work is being done. For instance, in many medical studies, a 5 percent ($p < 0.05$) level of significance is commonly used. In engineering studies, the acceptable level of significance is usually lower.

The *statistical method* used should be described completely in the Materials and Methods section. The description should include the type of statistics used, the number of degrees of freedom, which is most often derived from the number of samples already reported in that section, and whether the probability is determined from a one- or two-tailed population. If a one-tailed population is used, an appropriate justification must be given. In the Results section, only the *p* level should be reported; the value of intermediate statistical measures are usually of little interest or value to the reader.

Tense

Although at times it may seem awkward, it is correct form to keep the same tense in each section of the paper. "Shifting from one tense to another gives the appearance of uncertainty and irresolution" [1]. In certain sections of the paper, there is little choice as to what the tense should be. Materials and Methods describes what work was done and must be in the past tense. The Results section describes what results were obtained and must be in the past tense. The Introduction is a section that can have other tenses. In describing the significance of the problem, the present tense can be used. When describing past work of other investigators the past tense would make more sense. One of those tenses should be selected and all sentences in that section should be tailored to that tense. Similarly, in the Discussion section several tenses can apply. The past tense is the most logical when discussing the experiments and their results. The present tense could be used when discussing current applications of the study and the future tense would be applicable if future improvements to the studies were discussed. Once again, one tense should be chosen for the entire Discussion and all of the sentences should be appropriately structured to match that tense.

Common Writing Mistakes

Here is a list of things to look for in writing a paper:

- **Format:** Does the layout match that described by the Instructions forAuthors? Is the correct format used for references? Is the Abstract the proper length?

Checking: Use a Spell Checker and make sure that words it does not recognize are spelled properly before you accept or include them in your personal dictionary. Read your paper. Spell-Checkers and Grammar-Checkers are not infallable. Words can be spelled correctly but used incorrectly, and vice versa. Triple-check your equations and calculations. You are responsible for the contents of your paper.

Sentences: Are all sentences well structured with a subject and predicate?Can long sentences be broken down into two or more? When using "this" and "it," make sure that the reader knows what you are referring to; better yet, write it out.

Paragraphs: No paragraph should have only one sentence. Can very long paragraphs be broken down to improve the transition of ideas?

Wording: Avoid overuse of specific words; look for synonyms. Never use the same word twice in a sentence (except for small words like 'the' or 'a'). Avoid using the same word twice in a paragraph. Are you using jargon terms than can be changed to more common terminology?

Tense: Is the tense within each section consistent?

Overall: Have you clearly and concisely introduced the problem, described the experiments, reported the results, discussed the experimental errors, and discussed how the results have solved or illuminated the problem?

Specific: The word *data* is plural (e.g., data are reported). Never use contractions. Always write in the active voice ("We performed these experiments" rather than "These experiments were performed").

Summary

Go to the laboratory and get your data. Sit down at your computer, with your dictionary, your style manual, your Instructions for Authors, and your notes within reach, and start writing. Write your article and print it out, double spaced, on paper to read and make corrections. Do not be concerned with the length of the paper at this stage. Repeat the editing process as many times as necessary until you are happy with the result and it fits into the page limit. At this stage have your coauthors read it and make suggestions. Print out the final copy and send it so that it arrives by May 1, 1995. Good luck in the IEEE EMBS/Whitaker Foundation Student Paper Competition!

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References

1. **Strunk W Jr, White EB:** *The Elements of Style*, Macmillan, NY, 1972.

Is referencing an art or an obligation?

Doing research is a big deal. Finding new explanations for phenomena is a big deal. Finding new ways to do things is also a big deal. Worldwide, research scientists work hard to give a better understanding to natural phenomena, and to develop new theories that will give a more complete picture of experimental results. Applied scientists enthusiastically try to find applications or new ways of using well-known knowledge.

In this quest, worldwide knowledge is based upon published works that have accumulated over time. Very often these publications can be difficult to find, since researchers work in many different languages and all have the right and obligation to publish in their own language.

This problem has existed since the beginning of the era of publication. However, this problem may have increased with the development of research capabilities in all countries. Many researchers were isolated, with poor access to the pool of existing and/or published knowledge. This is why it is quite common to find the same piece of work done or published in different languages, each stating that they are the first to do this work.

However, I remember my thesis supervisor advising us to go to the library to search and read related work in such a way that we would be able to give credit where it is due. I remember his vast knowledge of scientific literature and his references to many phenomena or solutions by the names of their discoverers and inventors. I understand that this might be not possible today, with the explosion of published papers and the increased number of journals.

Nowadays, we all have access to databases full of information, which allow everyone to get a complete view of the literature related to a particular problem. This great accessibility to other work allows a more rapid development of knowledge and a rapid growth of new applications. I think that all of us can see this effect.

However, this greater accessibility is not always properly used. In fact, often researchers, either intentionally or by lack of reviewing previous work, do not cite prior work. Often, the work is cited using detour, and readers can find, hidden inside another reference, the original work that led to the published research. There are also those who cite, but group many references in a bunch under a single heading, thereby effectively hiding the original work.

There is also another phenomenon in which authors want to please some potential reviewers by deliberately citing their work as opposed to the field's original work. It is not my intent to say that authors must not cite these particular works, but by bypassing the original, they tend to give inflated credit to work that is not the true original.

This editorial aims to point out that researchers have wonderful instruments available to them, which allow them to do extensive reviews of literature. However, it seems that many do not use these instruments to complete their knowledge and avoid duplication of previously published work. Researchers are pressed to get new—or what may be seen as new—results to please their supervisors, their granting bodies, etc. I personally hope that we can all make better use of the available literature search capabilities that technology has given us. It is very frustrating to read articles where a part of the reported work—or even all the work—has already been published.

The problem with references in papers submitted for publication isn't worse than it was in the past, but surprisingly, it is not less than it was before the development of high-tech search capabilities. It is a pity.

Hopefully this editorial will put forth the question of whether referencing is an art or an obligation. Maybe we will discover that it is an obligation.

Roger A. Lessard
Editor