How to write a contemporary scientific article

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Today scientists are drowned in information and have no time for reading all publications even in a specific area. Information is sifted and only a small fraction of articles is being read. Under circumstances, scientific articles have to be properly adjusted to pass through the superficial sifting. Here I present instructions for PhD students with almost serious advises on how to write (and how not to write) a contemporary scientific article. I argue that it should “tell a story” and should answer on the three main questions: Why, What and So what?

Therefore, since brevity is the soul of wit,
And tediousness the limbs and outward flourishes,
I will be brief. (W. Shakespeare [1])

INTRODUCTION

Science has been industrialized. It follows a market-driven Moor’s law [2]: the number of scientific publications is growing exponentially with time [3–5]. At the beginning of my scientific career, slightly more than thirty years ago, we had one “library day” per week. Then we could skip the lab and go to a library instead. It was crowded in our library. People were sitting there, browsing all newly received journals from the beginning to the end. The number of such journals could be counted by fingers. Today 24/7 would not be enough for reading all publications even in my specific area. I don’t even know titles of all relevant journals. Unfortunately, the dramatic growth of the quantity came at the expense of quality [5]. As a result, the signal-to-noise ratio in scientific literature is reduced. Reading more does not necessarily brings more knowledge. I believe that the number of articles read by each researcher did not increase much in the last three decades. We were reading a lot before and have to work as well. To cope with the overflow of information, we use some sifting procedures. Therefore, a contemporary article should be adopted for passing the superficial sifting.

Growing complexity of modern science together with its industrialization have led to narrowing of research specializations. We are no longer either experimentalists or theoreticians, but have a much finer distinction (check e.g., academic job announcements). Narrow specialization causes difficulties in communication between scientists. It is not uncommon that experts in the same area, sitting in the same conference room, barely understand each other. Therefore, a contemporary article should be written in a manner comprehensible by not-exactly-the-specialists in your field, which often coincides with the rest of scientific community.

Here I present instructions, that I used to give to my PhD students, on how to write (and how not to write) a contemporary scientific article. I argue that it should “tell a story” with a clear and straightforward message and should answer the three main questions: Why, What and So what? I hope that these instructions, together with many earlier advises [6–9], can help young scientists in writing more comprehensible papers with better chances to be noted by scientific community.

WHY, WHAT AND SO WHAT?

The goal of every author is be read, understood and appreciated. To succeed, first of all, the results should be of the highest scientific value. But it is also important that the style is properly adjusted to modern realities. The article should tell a straightforward and easily digestible story. Like a Hollywood movie, it should contain a prologue, an action and a happy end, which should answer the three main questions posted above.

Introduction is the prologue of the story. It should explain the motivation: Why was it necessary to spend efforts on this project and why the reader should read it?

Results represent the main action. It should describe What has been done. The action should not be long and boring otherwise a spectator will switch it off. “Brevity is the soul of wit” [1]. The story should keep readers attention. For that, it should have a clear red line, the message. The action should follow the main story and should not deviate to technical details, or be overloaded with irrelevant data (usually this is the vast majority of acquired experimental results). As in a kitchen: if you put everything in a soup, it will become indigestible. For many students this is counter-intuitive. Technicalities are dear to their hearts because they put so many efforts struggling with them. But it is important to “see the forest for the trees”. The message should be clear without technicalities. They do matter, but only after the paper is read and the message understood. Move them to Appendix, or Supplementary.

Apart from technicalities, many students tend to focus on problems and failures. The reason is the same - they represent the most painful and memorable moments of the project. A report on a successful work may sound like a complete disaster. The story must be written in a major key! If there are no successful results, nor a message to tell then the article should not be written in the first place. Otherwise, be positive! The reader doesn’t
Results:
Heterostructures were fabricated in the SERACOHW system at p = 2351.2 Pa, V = 301.75 V. Sizes varied in the range 3.2186(0) ± 1.120973 µm. Transport and magnetic measurements at T = 303.76 K were performed using the RETTAMON setup, including current-voltage characteristics, susceptibility and magnetoresistance. A program for data acquisition, based on the LV22-FPGA-RT-Python-C++ and the PXIe-8861 unit was employed. An article was written: [J. Very Imp. Discov. 13, 666 (2022)].

Results:
- Broke two probes
- Dropped a sample
- Crashed a computer
- Forgot to switch off a pump
- Temperature was unstable
- Could not cool below T = 0.1 mK
- Only five samples were measured
- Was unable to measure V < 1 fV
- Failed to obtain a general analytic solution

For more details see: Me et al., J. Very Imp. Discov. 13, 666 (2022).

FIG. 1. Typical mistakes made by students: extreme technicality (left) and extreme negativity (right).

need to know all your mistakes. There are infinite ways to do things wrong and only one to do it right. Describe how it was done in the end. For example, if the current was too small to be measured directly and an alternative indirect technique was used for this purpose, don’t write: “we failed to measure the current”. Write instead that “we estimated the current from lock-in measurements, as described in Ref. [10]”. In Figure 1 I sketched the two typical mistakes.

Finally, Discussion and Conclusions sections represent “the happy end”. They should answer on the toughest question So What? Here the key result, its novelty and importance have to be explicitly articulated. However, unlike in a movie, this should not be the first and only catharsis. For the message to sink in a human brain it has to be repeated three times. Therefore, to avoid misunderstanding, there should be: (i) a spoiler in the Introduction, (ii) a message claim in the Results and (iii) the moral in Conclusions.

Title and abstract.

Today we are not sitting in libraries, but are using internet: Google, Web of science, e.t.c. This makes the title, the abstract and the cover art of special importance because they are passing the first sifting grid. Especially the title. When I was a student, I was taught to write excruciatingly detailed titles. My first paper was called: “The extended Bean critical state model for superconducting 3-axes ellipsoid and its application for obtaining the bulk critical field \( H_{c1} \) and the pinning current \( J_c \) in high-\( T_c \) superconducting single crystals”. Informative, isn’t it? But today the title should be both informative and eye-catching. Unfortunately, these two requirements are often contradictory. Much stretching towards popular catchy titles leaves a bad after-taste. There should be some golden mean. If the choice is between informative and catchy titles, I definitely recommend the informative.

Yet, even in this case there is some flexibility. The title may be informative e.g. about the key result or the main message (which do not need to be identical). Keep in mind, that other researchers will be searching for information on a specific subject. The more closely your title reflects the content, the more successful will their search be, increasing the probability of your article to be read. Google search the chosen title yourself and see if it ends up in a right category.

Abstract appears at the second step of sifting. It should tell the story and bring the moral like a fairy tale in one sentence. This is not easy. The only advice I have - leave abstract writing to the end, when the first draft is ready and the message is crystallized.

Figures.

At the final stage of sifting, we look through the article (often from the end) and, just like kids browsing a new fairy tale book, we focus on Figures. Therefore, Figures should tell a self-consistent story like a comics book.

Students can hardly imagine that in old, pre-computer, times graphs were drawn by hand. Special draftsmen draw axes and symbols. Thanks to computers, modern articles contain much more detailed visual information. However, a misuse of computer graphics can lead to crowded and unintelligible pictures. A general advice: avoid insets and use the minimal amount of text in the Figures. Imagine that someone would like to repost a part of your graph. In this case overlapping with excessive information on the same graph would create a problem. The modern trend is to have Figures with several simple panels. This helps to tell a story in a sequential comics-book fashion.

I always recommend to start writing a paper by assembling Figures. They form a skeleton of a future article, which is then developed by adding text and description. In experimental work Figures represent a quintessence of
the article. They illustrate results and carry the message. It is not uncommon that the message is revealed only after arranging all the Figures.

References.

Every scientific journal requires fair representation of earlier publications, which puts an article in a proper historical perspective. Therefore, an article should contain a good volume of references. Too few raze questions if the authors are aware of the field, is the representation fair, or is the field important? Excessive self-citations cause irritation. Self-citations should not exceed 20-25 % of the total list. Try to include works from as many different research groups as possible. Think that the article will be reviewed by several experts in the field. They wouldn’t be happy if their important (as they think) work is not properly cited. Scientists can be very petty and picky when it comes to priorities.

The main purpose of a reference is to provide material for deeper reading on the subject. Make sure that each reference is cited in a relevant context. Read them all! Topical reviews are the trend of our time. They are useful for a quick orientation in the field. Unfortunately they also become a popular lazy reference about everything. I recommend to be restrictive with reviews. Cite original articles instead, both for providing focused information to readers and for giving a scientific respect to pioneers.

Submission.

Thoroughly check publication criteria in the chosen journal. Referees are asked to provide answers to specific questions (novelty, originality, impact, ... ). Try to put yourself in the referee’s shoes. Count on having at least one referee from outside your field. Things that are obvious to you may not be obvious to the referee. Address the specific questions in the text to help the referee.

Don’t rush with submission. Polish the text very carefully. Don’t ignore small details (e.g. mismatch of figure stiles, fonts colors, language, etc.). A good work written in a sloppy manner will get less credits. You may not have a chance to improve the manuscript afterwards. Let the finished manuscript rest for two weeks. You will likely discover that it reads somewhat differently, the logics is not as straight as it seemed to be, and the text contains bugs. Repeat this step until iterations converge and only then press the submit button.

CONCLUSIONS

I have argued that a modern article should answer the three main questions. Here I address them to myself:

Why? Our time with an overflow of information and a narrow specialization of researchers requires proper adjustment of epistolary scientific style. Contemporary articles should tell an easily digestible story with a clear red line and an explicit message in order to pass the superficial sifting process.

What? I’ve wrote down instructions, that I used to give to my PhD students. By the way, similar rules apply to conference presentations.

So what? I hope that presented advises can help students to write more comprehensible articles with a better chance to be noted by scientific community. Young scientists should learn the art of clear and laconic expression of ideas if they want to stay in academia. However, I want to emphasize that the best strategy for having your paper read is to maintain a good scientific reputation by not producing “scientific noise”. There are no magic tricks that could make a mediocre research good. Yet, even a good researcher, presenting excellent results, should try to help stressed and pressed contemporary readers.

[1] William Shakespeare, The Tragedie of Hamlet, Prince of Denmarke. (First Folio, London, 1623).
[2] G. E. Moore, Cramming more components onto integrated circuits. Electronics 38, 114 (1965).
[3] P. O. Larsen and M. von Ins, The rate of growth in scientific publication and the decline in coverage provided by Science Citation Index. Scientometrics 84, 575-603 (2010).
[4] L. Bornmann and R. Mutz, Growth rates of modern science: A bibliometric analysis based on the number of publications and cited references. J. ASIS&T 66, 2215-2222 (2015).
[5] R. Seppelt, M. Beckmann, T. Václavík, and M. Volk, The Art of Scientific Performance. Trends in Ecology & Evolution 33, 805-809 (2018).
[6] See, e.g.: https://www.awelu.lu.se/genres/writing-in-academic-genres/popular-science-writing/
[7] J. R. Matthews, and R. W. Matthews, Successful Scientific Writing, 4th Ed. (Cambridge Univ. Press UK, 2014)
[8] F. M. Menger, S. A. A. Rizvi, An Essay on Scientific Writing. Education 3, 130 (2013).
[9] S. P. Turbek, T. M. Chock, K. Donahue, C. A. Havrilla, A. M. Oliverio, S. K. Polutchko, L. G. Shoemaker, and Lara Vimercati, Scientific Writing Made Easy: A Step-by-Step Guide to Undergraduate Writing in the Biological Sciences. The Bulletin of the Ecological Society of America 97, 418 (2016).
[10] R. A. Hovhannisyan, O. M. Kapran, T. Golod and V. M. Krasnov, Accurate Determination of the Josephson Critical Current by Lock-In Measurements. Nanomaterials 11, 2058 (2021). Just a close to hand example, sorry for self-citation.