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How to Write a Good Scientific Paper: Authorship

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This is the fourth in a planned series of editorials covering all aspects of good science writing

Who deserves credit for the work reported in a scientific paper? That is the basic question of science authorship since, unlike authorship credit in the world of creative writing, what matters most for scientific papers are the ideas rather than the words. On the surface, it would seem that deciding who belongs in the list of authors would not be a difficult task. But the affairs of humans are rarely straightforward, and authorship controversies are not uncommon in the world of science and engineering.

Big-project physics papers often have hundreds of authors (the most I've seen is more than 2,000 authors¹), a situation that many lament but few are willing to address. There are likely some scientists who have not read a majority of their own papers. The growing average number of authors per paper over the last 50 years may represent a trend toward increasing collaboration in science, or it may indicate author inflation, where including more authors is simply a way of building resumes.² Ethical lapses regarding medical and pharmaceutical papers often center around companies that write the papers and then find academics willing to attach their names to them.^{3,4}

Purposely misrepresenting the true authorship of a paper is an act of fraudulent publication⁵ and is commonly the result of motivations other than the advancement of science. A 2005 survey found that about 10% of authors admitted to inappropriately assigning authorship credit over the previous three years.⁶ While I'm sure many or most of these inappropriate assignments were not intended to deceive, such ethical lapses still can have important consequences. The public's trust in science, arguably essential for the progress of civilization, depends in part on the belief that most scientists are honorable and motivated primarily by a desire to advance science. Anything that challenges those beliefs, including ethical failures regarding authorship, can only have a damaging effect on the public's trust.

To address these issues, and to ensure that they are not affecting our JM3 community, a detailed discussion on what it means to be an author is needed.

1 Defining Authorship

Let me take a stab at a definition for authorship appropriate to scientific papers:

An author of a scientific paper is anyone who has made a creative contribution to the words or ideas being presented that are claimed to be novel.

Obviously, authorship of the words and figures used in the paper (the conventional definition of authorship) counts as authorship for a scientific paper. If using a person's words in the paper would amount to plagiarism without that person being listed as an author, then that person must be listed as an author or must be quoted and cited. But contributions to the concept, design, execution, or interpretation of the work also count.⁷ Most definitions of authorship claim that such

contributions must be "significant." But the interpretation of "significant" is ambiguous at best and fails to capture the true spirit of authorship in the world of science. In my mind, the key to this definition is that only *creative* contributions count toward authorship.

To understand what a creative contribution is, consider the first characteristic of a scientific paper that makes it publishable: it must be novel. A creative contribution to the work is an intellectual contribution to the *novel* aspects of the work. To determine the proper list of authors for a paper, first ask "What is novel about this work?" Then ask, "Who contributed to the creation of this novel content?"

There is one more critical aspect of authorship. While the focus so far has been on the proper apportionment of credit (which is a matter of fairness), authorship also comes with responsibility (which is a matter of accountability). "An author who is willing to take credit for a paper must also bear responsibility for its contents."⁸ And what are an author's responsibilities? Before publication, authors are responsible for their ethical behavior during the research leading to the paper and for the ethical presentation of their results. After publication, the authors are collectively responsible for publicly answering any concerns or criticisms of that work. Scientific advances build on past knowledge, and a scientific publication is of value only so far as it integrates into the communal collection of knowledge.⁹ Thus, the author's responsibilities do not end at publication. Authors must be willing and able to answer for their work to the larger scientific community.

For this reason, it is critical that all authors approve the manuscript before it is submitted for publication and approve all changes made to the manuscript during the review and revision process. Personally, I have been surprised more than once to find my name attached to a published paper (conference papers, not peer-reviewed, thankfully) without ever seeing the paper or even knowing I was an author, a phenomenon called "surprise authorship."¹⁰ My "co-authors" were well intentioned, probably realizing at the last minute that I had contributed some idea found in the paper (most likely during an argument taking place over beers). Not wanting to dismiss my contribution or face the possibility of an angry colleague, they played it "safe" and added my name before sending the paper in. Undoubtedly, a mention in the acknowledgments would have been far more appropriate.

We now have a definition of authorship and an understanding of the responsibilities that come with that designation. Based on this, here is a three-part test for authorship:

1. Has the person made a creative contribution to the work? Note that contributions include writing the manuscript and/or involvement in the conception, design, execution, or interpretation of the work. A creative contribution is an intellectual contribution that enhances the novel aspects of the work.
2. Has the person reviewed and approved the final manuscript prior to submission for publication?

3. Does the person accept the responsibilities that come with authorship, including a willingness and ability to answer criticism?

To be listed as an author, the person must be able to answer yes to all three parts of this test. But, importantly, anyone who answers yes to the first question is ethically obligated to attempt to answer yes to the second two questions to the best of their ability. No one should use the last two questions of the above test as an excuse to exclude someone (or themselves) who otherwise should be an author.¹¹

Some examples of work that is important to the paper but does not make a creative contribution (that is, does not add to or enhance what is novel about the paper) include:

- preparing materials or operating equipment using standard methods, even if such work is extensive
- applying routine statistical tests or analysis without interpretation
- routine reviewing, proof reading, or editing of the manuscript
- supervising the people involved in the work, approving their projects, or securing resources.

People performing the above tasks can be acknowledged, but those tasks alone do not justify inclusion in the list of authors. Certainly, people performing these tasks may also have contributed to the novelty of the work, and if so deserve author status.

The criterion for authorship changes with the type of science publication. Popular science books, textbooks, and review papers often have just one or two authors, where the definition of authorship reverts to the creative writing definition: the authors are the ones who created the words and expressions, including figures, in the document. The above discussion applies to science journal papers, where it is the new science being reported that matters most.

2 No Guests or Ghosts

There are two ways to err in listing the authors for a manuscript: leaving off someone who belongs on the list (a *ghost* author) and including someone who doesn't belong on the list (a *guest* author). Both errors are reasonably common in scientific publishing for different reasons, and both can be serious problems with different consequences. Usually, such mistakes are unintentional and are often the result of not fully knowing the requirements for authorship. Sometimes, though, the mistake is not so innocent and can represent a serious breach in ethics.

A guest author is generally added to a paper with the best of intentions: the sin of including an undeserving author is often thought to be less egregious than the sin of omitting a deserving one. When in doubt, add them as an author, the thought goes. But guest authorship is not a victimless crime. Their inclusion dilutes the credit due to the valid authors and inflates the credit due the guest. And since each author is responsible for the content of the paper, guest authors are put at risk should there be a problem or controversy about the paper that must be addressed.

But guest authorship is not always so innocent. Sometimes a supervisor, lab director, or some other person of authority insists that his or her name be included on all publications under his or her control. Guest authorship by coercion is an intolerable violation of professional ethics. Again, the definition and tests above should be enough to determine whether a supervisor or other authority figure belongs on the author list. In an academic setting, the “publish or perish” mentality can lead to poor decisions as well, with colleagues helping to pad each other's resumes by including each other on their publications after only the slightest of interactions. Sometimes an “honorary” author is added to help the paper get accepted by the journal or to curry favor with an important person.

A second class of guest authorship is often more pernicious when commercial interests are at stake. If the paper describes products or outcomes that could influence the sales of a product, the parties benefiting commercially may feel a desire to hide the extent of their involvement in the work. Sometimes this results in guest authors, ghost authors (to be discussed below), or both. Often, a customer of the product is listed as an author (even the first author) to provide a sort of customer endorsement. I personally know of papers where customers were listed as authors even though their only contribution was to buy the product described in the paper. More frequently, however, the customer supplies access to equipment or materials and may even collect some or all of the data. But if customers' contributions can't be described as creative, they shouldn't be listed as authors—it makes no difference that the goal of the project may have been to generate a “customer paper” to show off the benefits of the product. I understand that scientific papers are sometimes used as marketing tools, but their scientific value and integrity must and will be judged independent of any such considerations.

Ghost authors are sometimes left out by oversight, though in my experience this is rare. Certainly there can be disagreement as to which contributors rise to the level of author. Open and frank discussions with all of the parties involved, throughout the research cycle, are the best way to prevent misunderstanding and conflict over authorship without resorting to the crutch of listing everyone as an author to avoid conflict. The bigger problem comes when ghost authorship is intentional. Again, the most common cause is commercial interest, where some authors may wish to hide their involvement to mask their all-too-obvious conflicts of interest. A less nefarious but still serious problem occurs when an engineer or scientist hands a jumbled mass of notes and data to the marketing and communications department (or contractor) of his or her company, which then turns it into a paragon of clarity and erudition—but without receiving due credit. Occasionally a deserving author is left off the paper simply because he or she moved to a different company (maybe even a competitor) or university. Company affiliation should play no role in determining authorship for a work.

3 Don't Forget the Acknowledgments

Most authors think about an acknowledgments section to their paper at the last minute, if at all. “Don't forget to mention our

funding source,” one of the coauthors scribbles on a late draft. However, acknowledgments are extremely important for recognizing all those who contributed to the work but whose contributions did not rise to the level of authorship. This is where the technician, the supervisor, or the colleague whose work was important but not part of the novel aspects of the paper is listed. If you thought about the possibility of including someone on the authors list but didn’t, chances are that person belongs in the acknowledgments section, with a description of his or her contribution.

4 Author Order

Since the dual purposes of defining authorship are to assign both credit and responsibility for the work, the case of multiple authors begs the question of how much credit and responsibility should accrue to each author. Within most scientific communities, author order in the list of authors serves as a proxy for assigning both credit and responsibility. With many exceptions (some of which will be discussed below), the first author is generally assumed to be the one to whom most credit and responsibility accrue. Authors are then ordered according to decreasing contribution to the work. But different communities have different cultures, and this system of author ordering is not universal.

The problems with such a system are obvious: it is often difficult if not impossible to determine which contributors deserve more credit. In fact, it is not clear that such a rank ordering is even desirable, at least in some cases. What if two coauthors agree that their contributions were equal? How can significantly different kinds of contributions be compared? If one author contributes most to the theory, another to the experiment, and a third to the analysis, whose contribution is most valuable? If one person conceives of the work and another carries it out (typical of a mentor relationship), who deserves the most credit?

Because of these problems, two other systems of determining author order have become common. The first is to simply disconnect author order from level of credit by always listing authors alphabetically. The culture of mathematics journals is to list authors alphabetically, and this practice is almost universally followed. The fact that many mathematics papers have one or a very few authors may make this practice easier to adopt. Another system is quite common when publishing involves the work of PhD students or postdocs. Here, the work generally represents the thesis project of one student, who is then assigned the first author spot. That student’s supervisor is assigned the last author position. In between, author order is determined by level of contribution, but with students generally listed first and professors last. This nifty system deals very well with the category problem: how can we compare the importance of the contributions of the student/postdoc and the mentor? We simply don’t make the comparison, recognizing that the student/mentor relationship is too important to be turned into a competition.

Assigning author order can sometimes be contentious and can become especially difficult when multiple groups work collaboratively on a project. One potential solution is to add a paragraph to the paper (at the end, or as a footnote) outlining the specific contributions of each author.¹² That way,

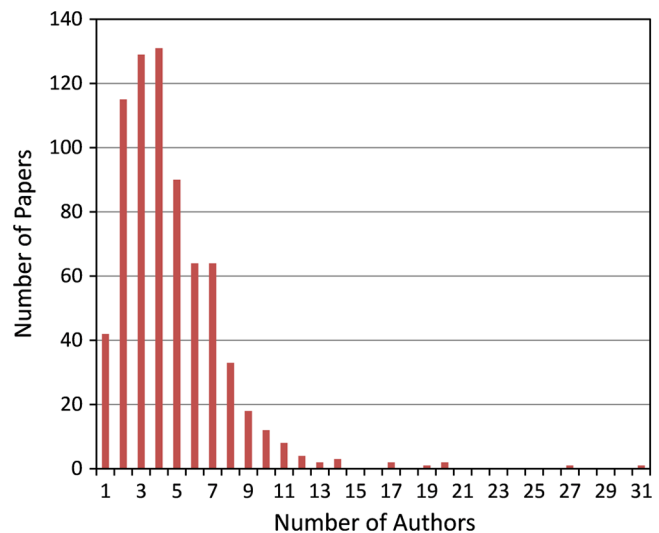


Fig. 1 Number of JM3 authors per paper, 2002–2011.

readers can judge for themselves whose contribution deserves the most credit.

5 Authorship within JM3

Is poor application of the above criteria for authorship a problem at JM3? Let’s take a look at some data. Over the first 10 years of JM3 history, 2002–2011, the number of authors per paper followed a skewed distribution (as one would expect—see Fig. 1). The average number of authors per paper was 4.7 (standard deviation of 3.0), while the median number was 4, which was also the mode. Only 6% of papers had a single author, while 5% of papers had 10 or more authors, and 1% had 15 or more authors. The maximum number of authors was 31. One wonders if all 31 of those coauthors would have passed the authorship test described above. Maybe; it was a new lithography system paper, where doubtless many people contributed to the development of the novel aspects of the new lithography tool. But unless all authors conscientiously apply the above criteria to their work before submitting a manuscript to be published, chances are that guest and ghost authors will both be common.

6 Conclusions

Authorship is an important issue in the world of science. Reputations, even legacies, are often built on a history of publications. The two ethical principles of fairness and accountability are tied into the practice of assigning authorship for scientific papers. The definition of authorship proposed above, and the proper application of the proposed authorship test, can help ensure that authorship decisions contribute to, rather than detract from, the proper pursuit of science. Though I’m sure that anyone determined enough can find or create a loophole to justify a predetermined authorship decision, following the spirit of this proposal should alleviate most concerns and conflicts regarding authorship.

Finally, I should note that standards of authorship are to a certain extent cultural, meaning that different communities

(disciplines) of scientists set their own standards within the wider culture of science as a whole. The opinions I have expressed in this editorial reflect what I feel are the correct positions for the JM3 community. They may not be a perfect match to every discipline of science and engineering, though I suspect that they are not too far off for most scientific communities.

Chris Mack
Editor-in-Chief



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