Bringing up scientists in the art of critiquing research

by Barbara J. Kuyper

In addition to factual knowledge of a given discipline, scientifically literate college graduates need analytical skills to interpret, apply, and communicate the scientific information they have acquired (AAAS 1990, NAS 1989). For research scientists, analytical skills are essential in writing, critiquing, revising, and defending research proposals and articles and reviewing the research of other scientists. Critical thinking and writing are activities integral, rather than peripheral, to scientific research. As Sidney Perkowitz (1989) of Emory University writes, "I have learned that when I write a research paper I do far more than summarize conclusions already neatly stored in my mind. Rather, the writing process is where I carry out the final comprehension, analysis, and synthesis of my results" (p. 353).

But graduate students rarely receive formal training in thinking or writing about research. Many become good scientists who are nonetheless severely handicapped in communicating their own research and in eliciting useful assessments of it from others. With a good analytical mind and a few other tools at hand, however, a scientist at any career stage can learn the art of critiquing research.

Critical assessment of research articles

Traditionally, the scientific method involves formulating a hypothesis, designing an experiment to test the hypothesis, collecting data, and interpreting the data. The structure of research articles (called IMRAD) parallels this sequence: introduction, including statement of objective; methods; results; and discussion. The model for conducting research and the structure for presenting it have variations, but the basic analogy remains. Research is conducted and presented by the scientific method, and it can also be analyzed by using the same logical sequence of steps.

Critical assessment of a research article appropriately occurs at several stages. The author critiques the first draft and revises it accordingly. Friendly colleagues review the revised draft, and the author revises the manuscript again in the light of their suggestions. These presubmission critiques and revisions are intended to improve the written presentation of research, short-circuit unfavorable reviews, and decrease time to publication. On submission, the article undergoes peer review to determine acceptability for publication. When an article enters the scientific literature, it becomes open to scrutiny by other scientists, as well as by journalists, politicians, and the general public, and at this stage a scientist's reputation can be firmly established or irrevocably damaged.

The value of being able to self-critique manuscripts and to have confidence in the critique cannot be overemphasized. A scientist should ask, "What was my bias in carrying out procedures or in collecting data? Did I want my results to happen?" Scientists are human and thus subjective, and awareness of one's own subjectivity is essential in preparing objective research results for presentation to the scientific community (Harper 1990).

For the same reason, scientists need to learn how to elicit useful critiques from colleagues. "Is my bias showing? Can you tell what I'm most afraid of? Can you detect any weaknesses in my experimental design or methodology that an incisive reader will most certainly expose if you don't? As a friendly colleague, I'd like you to tell me before a journalist tells the world!"

Developing skills in critiquing research

Some tools are needed for training scientists to critique their own and their colleagues' research articles. An analytical mind-set is basic to all facets of scientific research, including critical analysis of the scientific literature. In editing manuscripts for research scientists, I prepare a written summary that assesses the article section by section. This editorial critique is designed to give the author an overview of the manuscript rather than getting bogged down in editorial clean-up work or a sentence-by-sentence analysis. A colleague's written critique also provides an overview, but it emphasizes design and interpretation of research rather than presentation. The checklist, a traditional editors' tool, is also useful in scrutinizing scientific manuscripts from authors', statisticians', and reviewers' standpoints (Applewhite 1979, CBE Style Manual Committee 1983, Gardner et al. 1986, Squires 1990).

I have developed a checklist for critiquing a research article at an early draft stage that both the author and in-house reviewers can use (see box page 249). The checklist focuses on structure, or organization, and its interrelationship with content. It is based on the IMRAD structure but can be modified for other types of journal articles. In assessing articles with the aid of the checklist, fluorescent color markers are useful tools that give authors and reviewers something useful (and playful) to do. I use a yellow marker to call attention to statements of objectives at various points in the manuscript (and discrepancies among them) and a rose marker to identify undefined or misused terms.

A critique of the introduction alone (steps 1–4) sometimes unravels the

Checklist for critiquing a research article

Title _____ Author _____

Introduction

__ 1. Read the statement of purpose at the end of the introduction. What was the objective of the study?
__ 2. Consider the title. Does it precisely state the subject of the paper?
__ 3. Read the statement of purpose in the abstract. Does it match that in the introduction?
__ 4. Check the sequence of statements in the introduction. Does all information lead directly to the purpose of the study?

Methods

__ 5. Review all methods in relation to the objective of the study. Are the methods valid for studying this problem?
__ 6. Check the methods for essential information. Could the study be duplicated from the information given?
__ 7. Review the methods for possible fatal flaws. Is the sample selection adequate? Is the experimental design appropriate?
__ 8. Check the sequence of statements in the methods. Does all information belong in the methods? Can the methods be subdivided for greater clarity?

Results

__ 9. Scrutinize the data, as presented in tables and illustrations. Does the title or legend accurately describe content? Are column headings and labels accurate? Are the data organized for ready comparison and interpretation?
__ 10. Review the results as presented in the text while referring to data in the tables and illustrations. Does the text complement, and not simply repeat, data? Are there discrepancies in results between text and tables?
__ 11. Check all calculations and presentation of data.
__ 12. Review the results in the light of the stated objective. Does the study reveal what the researcher intended?

Discussion

__ 13. Check the interpretation against the results. Does the discussion merely repeat the results? Does the interpretation arise logically from the data, or is it too far-fetched? Have shortcomings of the research been addressed?
__ 14. Compare the interpretation to related studies cited in the article. Is the interpretation at odds or in line with other researchers' thinking?
__ 15. Consider the published research on this topic. Have all key studies been considered?
__ 16. Reflect on directions for future research. Has the author suggested further work?

Overview

__ 17. Consider the journal for which the article is intended. Are the topic and format appropriate for that journal?
__ 18. Reread the abstract. Does it accurately summarize the article?
__ 19. Check the structure of the article (first headings and then paragraphing). Is all material organized under the appropriate heading? Are sections subdivided logically into subsections or paragraphs?
__ 20. Reflect on the author's thinking and writing style. Does the author present this research logically and clearly?

entire article. Discrepancies between the title of the article and the stated objective at the end of the introduction throb in the fluorescent color. The researcher may discover an ambiguity in thinking about the purpose of the research that was previously concealed but is now glaringly obvious.

A careful scrutiny of research methods (steps 5–8) may expose fatal flaws in sample selection or experimental design that invalidate the results. This disturbing revelation can be beneficial over the long run, however, if it helps the scientist to cut losses and move on to better-defined research. A review of methods on completion of a research project can also emphasize the importance of choosing an appropriate experimental design at the onset and evaluating the research project as it develops.

The results, particularly as presented in tables and illustrations, almost inevitably require drastic redesign and revision. Selecting, aligning, and labeling data appropriately in tables require as much thought as does the textual description of results. Ideally, the author has designed the tables before writing the results section, and steps 9–12 on the checklist directs reviewers to examine the tables first. A table should be self-explanatory, with a title that accurately and concisely describes content and column headings that accurately describe information in the cells. Instructions for preparing scientific tables (CBE Style Manual Committee 1983) and illustrations (CBE Scientific Illustration Committee 1988) are invaluable tools in writing and revising research articles.

Authors often seem mentally fatigued by the time they have defined in writing what their research was really about, struggled with statistical analysis of data, sorted out meaningful results, and revised tables again and again. Consequently, the discussion often degenerates into a feeble rewording of results rather than interpretation of the research and its status in relation to other studies in the field. In critiquing the discussion section (steps 13–16), the author can easily detect mere repetition of results. To validate and refine interpretation, however, a colleague's probing questions are probably more fruitful at

this stage than is self-examination.

The overview section of the checklist (steps 17–20) requires the author or reviewer to step back and reconsider the manuscript as a whole. Does the author think and write logically? Is the organizational sequence of the paper logical and appropriate to content? Are the objectives and results of the research stated clearly? Does the article fit the stated purpose of the journal to which it is being submitted?

Conclusions

After all is said and done, critiquing research is intellectual fun. The ability to scrutinize a piece of writing with a critical eye requires time for leisurely contemplation, an analytical mind (the scientific mind?), a zest for arguing with colleagues, and the ability to set ego aside. If we do not assess our own research, journal reviewers and subsequent readers will do it for us, with the potential for much more badly bruised egos and scientific reputations.

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