A

Writing a Brief Instrumentation Paper

A thorough description of the characterisation of an instrument is an essential prerequisite for a scientific study in which it is used. Such a primary source of information is important, as, if the instrument itself is well described and summarised, the scientific results obtained from its use ought to be subject to fewer doubts, ultimately giving more confidence in the overall findings. More pragmatically, if an instrument has been designed and made specifically for a particular investigation, without such a publication there may otherwise be no record of its existence.

A.1 Scope of an instrument paper

An instrument description can usefully be separated from the study in which it is used, either by putting the instrumentation aspects in an appendix to the main paper, or, if it contains original material, by publishing a self-contained short paper (often called a Note) describing the instrument and the tests and calibration checks made. Novelty is needed for the description to be publishable in this way, in an instrumentation journal such as *Reviews of Scientific Instruments* or *Measurement Science and Technology*.

A.2 Structure of an instrument paper

An instrument Note would generally consist of the following elements: *Title*, *Abstract*, *Motivation* , *Instrument description*, *Calibration* or comparison with another instrument, *Summary*. A few relevant references to earlier work are also essential for placing the novelty of the new device or approach in context. The different elements of an instrument note are now briefly summarised.

A.2.1 Paper title

A well-chosen title serves to define the content of an instrumentation paper and ideally should give the scope and relevance of its content. For example, beginning the title with ‘A balloon-borne…’ or ending with ‘…for atmospheric temperature measurements’, gives immediate context and the likely application.

A.2.2 Abstract

The Abstract is a short summary of the content of a paper. After a paper's publication, its Abstract is likely to be discovered through using search tools, and depending on the journal's publication policy, it will probably be available free. Combined with the title, the Abstract therefore forms an important aspect of the marketing of the final published work to a broad audience.

A typical Abstract is usually 100 to 200 words in length. Generally the Abstract can therefore only consist of about half a dozen sentences, the first couple giving the motivation and context, the second couple summarizing the evidence supporting the function of the device, quantitatively if possible, and a final couple describing the likely application and any limitations. Conciseness in the Abstract is important, through the use of short sentences and punctuation to separate different ideas (although using too many adjectives or hyphens can make it difficult to read). Numerical quantities need to be presented carefully, with units and uncertainties, for example ‘The sensitivity of the sensor was (3 ± 1) V K^{-1}…’ An Abstract almost never contains references, except for some journals which specifically require an introductory paragraph rather than an Abstract, or (and this is rare), when the work of one particular previous paper is central to the new work presented.

A.2.3 Keywords

Keywords are sometimes used for indexing. The keywords should not be words which appear in a title, but instead be fundamentally different ways of describing the content of the paper. For inter-disciplinary work, it is worth considering if the keywords would be understood by the different audience of another discipline, or if they are so technical that they can only be understood by one discipline.

A.2.4 Motivation

An instrument paper normally begins with some motivation for the work which was undertaken, which is usually about the reasons for the measurements concerned. This need not be a long section, but usually a broad statement about the general subject area would be made first, followed by several further sentences refining the topic to the nature of the problem to be discussed. References to previous work will be needed. It will almost certainly not be possible to mention all the relevant references, especially in a short note, but if there is a key historical reference, or a relevant review paper, it should be included, together with a few recent references.

A.2.5 Description

The next part of the paper seeks to describe the instrument from several perspectives, with the intention of conveying the principles used and any particular novel approach or technique needed for it to work correctly. This can be achieved using cogent and succinct text, particularly if it refers to a block diagram, an annotated functional drawing or an electronic circuit diagram. (Links in the text to the relevant figure being described will be needed.) In writing this, the object is not to provide an entire set of assembly instructions, but to provide sufficient information either to reproduce the instrument in another well-equipped development laboratory or for an instrumentation scientist to understand how the instrument functions. Annotated photographs may not copy very well when the work is reproduced, so schematic or outline diagrams are preferable in ensuring the work is understood correctly.

A.2.6 Comparison

The major finding of an instrumentation paper is usually about how well the instrument works and its range of application. This can most simply be achieved by a comparison with a better known or standard instrument, but alternatively it may require the generation of reference signals for calibration. In either case, a plot showing the instrument's response compared with either the standard instrument or standard values will be needed.

A.2.7 Figures

Figures should be compact, in that they should concentrate on displaying the available information obtained from the experiments. For this reason, extensive legends are worth avoiding, as they consume valuable plotting area of data. An explanatory caption is a useful alternative.

Figure captions themselves also require careful attention. A good caption is entirely self-contained, and provides all relevant information required to understand the figure without recourse to the main text. If the figure has several parts, the caption must address each of them.[1] Occasionally, it may be possible to provide a point or two of experimental detail in a caption, such as '…obtained using a hand-held anemometer under steady wind conditions', but the caption is not a place where the data should be interpreted in anything other than the simplest way (e.g. '…points concerned with the region of interest are marked'). Instead, the detailed discussion and interpretation should be provided in the main text, with a cross-link made to the figure when needed.

The convention of the *x*-axis carrying the independent variable (the quantity which can be changed) and the *y*-axis carrying the dependent variable (the response in the instrument), is usually interpreted to show values from the standard instrument on the *x*-axis with values from the instrument investigated shown on the *y*-axis. The scatter in the points can be informative, as are any error bars which can be added to the points. In some cases, a statistical fit determining the sensitivity of the response or a line allowing a comparison with theory may be a worthwhile addition.

Care is particularly needed in ensuring that the scales and units of the axes are clear and as simple as possible, for example using standard form or SI prefixes such as ‘air temperature (°C)’, ‘droplet size (μm)’ or ‘thermistor resistance ($\times 10^4$ Ω)’ to indicate that the quantities on the axis are in units of 10^4 Ω. If several plots are needed, these should be organised so that, as far as possible, axes with the same quantities are aligned, and have the same plotting range. For example, if two thermometers were separately compared with a standard thermometer, using two square plots aligned as a pair left and right with the same vertical axis range in each case would also allow a comparison between the two experiments. A further possibility in characterising the response is to plot the difference between the two instrument readings against the standard values.

A.2.8 Summary

The closing part of the paper collects together the findings, and emphasises the main points. There is no need to repeat what has been done except in the barest outline if there is a specific aspect to be drawn out, and there should be no repetition of earlier text or phrases in the Abstract. This is also not a place where new material is introduced. (If it is found that a fundamentally new point has to be made, an earlier section, such as the motivation or instrument comparison, should be modified and extended accordingly.)

A.2.9 Acknowledgements

Acknowledgements at the end should thank those on whose contributions the work's existence has depended, such as technicians and funding bodies, with a short grant reference code if appropriate.

A.3 Submission and revisions

The completed paper, checked for errors and correct figures, will be submitted to the selected instrumentation journal through its website. As for the peer-reviewed scientific literature in

general, the journal will send a submitted paper to referees selected for the relevant expertise to the work discussed. After the referees have produced review reports, usually anonymously, the reviews will be sent to the author by the journal editor. The editor of the journal will usually indicate at this stage whether, if the review comments are addressed, the paper is likely to be published. (The editor may of course also decide to reject the paper on the basis of the review reports.)

In responding to review comments, it is conventional to deal with the points made separately, and indicate where in the manuscript changes have been made to address the review comments. If this is done clearly and straightforwardly, for example by marking the changes made in colour, it will make the job of the editor easier. Polite and constructive responses at this stage also form part of the orthodoxy of scientific interaction, in part because they may also offer the best prospects of conveying clarity of thought.

Note

1 A good test for whether the different parts of the figure can usefully be grouped together is to consider whether the combined caption is shorter than a set of individual captions.