

Try to pick a catchy title!

# RULES OF THUMB FOR WRITING RESEARCH ARTICLES<sup>1</sup>

Tomislav Hengl<sup>A</sup>, Michael Gould<sup>B</sup>

<sup>A</sup>International Institute of Geo-Information Science and Earth Observation (ITC), P.O. Box 6, 7500 AA Enschede, Netherlands, hengl@itc.nl

<sup>B</sup>Michael Gould Associates, Apeldoornseweg 21, 6814 BG Arnhem, Netherlands  
mike.gould@mgassoc.demon.nl

Web: <http://www.itc.nl/personal/hengl/RT/>

## Abstract

The paper provides 'rules of thumb' for writing research articles (RA) and getting them published. These were discussed during the "Scientific writing course" organized for ITC PhD students by Cressie Communication Services. Important aspects of macro and sub-structure of a paper were selected through group discussions. The substructure and functions of different sections of RAs are described. Results of previous investigations and interviews among journal editors were used to summarize what makes a good RA. It was concluded that clear, logical, coherent, focused, good argument and well-structured writing gets the paper published and read. Some important rules of the thumb selected were: "Adjust your writing to the audience and purpose", "Avoid redundancy and unnecessary explanations" and "Write like you speak and then revise".

abstract should be short but give the overall idea: what was done, what was found and what are the main conclusions

**Keywords:** Research article, rules of thumb, structure, publishing.

when selecting KWs, imagine you are searching for your article in some database

## I. INTRODUCTION

A scientific or research article or paper is a technical (or essayistic?) document that describes a significant experimental, theoretical or observational extension of current knowledge, or advances in the practical application of known principles (O'Conner and Woodford, 1976). It is important to emphasize that a research article (further referred as RA) should report on research findings that are not only sound (valid) and previously unpublished (original), but also add some new understanding, observation, proofs, i.e. potentially important information (Gordon, 1983). Unlike a novel, newspaper article or an essay, a RA has a required structure and style, which is by international consensus known as "Introduction Methods Results and Discussion" or IMRaD. However, a RA is not only a technically rigid document, but also a subjective intellectual product that unavoidably reflects personal opinions and beliefs. Therefore, it requires good skills in both structuring and phrasing the discoveries and thoughts. These skills are acquired through experience, but can also be taught.

MOVE 1: Introduce the topic and emphasize why is it important!

MOVE 2: Relate to current knowledge:

Many books have been written on general guidelines and rules to help scientists write RAs (Day, 1994; Trelease, 1958). These days, many scientific societies and groups write quite detailed publications and style manuals to help both authors and publishers to get along; see for example the CBE's style manual (1994) or the ACA-CSA-SSSA's

<sup>1</sup> You are free to distribute this document, or use it in class, as long as you give credit to the source and you don't use it for any commercial purposes. In Enschede, September 2002.

manual (1998). What used to be short guides for writing a RA has been extended to the level of meso and micro-elements of the paper. Various authors have investigated the principles of creating a good title (Ackles, 1996), writing a good abstract or introduction (McPhee, 2001; Swales, 1981). Some go to the level of the micro-structure of RA (sentences) and provide a framework for a logical structure between the words (Gopen and Swan, 1990; Kirman, 1992). However, writing a RA is still a "monkey-puzzle tree", especially if you are a non-native English speaker (further referred to as L2). What makes a good paper and which rules of thumb are the most important for these researchers?

"What's been done" and "What needs to be done?"

Bring the GAP



MOVE 3: Introduce your work Give the purpose and main objective

Following this question, we tried to formulate some rule of thumbs for easier writing (or better to say publishing) of RAs. These rules gathered from discussions during the "Scientific writing for non-native English speakers" course, but also come from our personal experiences with scientific writing. The main idea was to summarize main conclusions from these discussions and bring them all together in a form of a paper.

Objective



## II. METHODOLOGY

The Scientific writing course, organized annually for ITC PhD students, was held in period from March 8<sup>th</sup> until April 26<sup>th</sup> 2002. There were nine students, who followed five full-day classes. This gave enough time to do numerous home-works and assignments. The classes were organised in a way that participants worked in groups or individually and discussed the most important issues, first among themselves and then as a whole group. The following topics were discussed in more detail (in chronological order): standard structure or elements of an RA, macro, meso and micro levels of a RA, general problems with readability and communication, functions and content of Introduction, Methods, Results and Discussion section, writing successful abstracts and principles of submitting and publishing a RA. The participants were from eight countries (L2) and four continents, which was a ground for discussion of cultural-academic differences (Prince et al., 1999). The working material and facilities were organized by Ian Cressie (Cressie, 2002), while most of the classes were lead by Michael Gould, documentation consultant and advisory editor. Participants generated some graphs and flow diagrams manually (Fig. 1), which we then modified and transferred to a manuscript form.

Describe Experimental set-up

Object of the study



Explain used techniques

Establish an author's 'voice'



Fig. 1. Photo from the Scientific writing class at ITC. Discussion about the "Discussion" section.

The basic concept of the course is that the students should learn from the real examples and on their own mistakes. In most of the cases, participants were analysing and correcting each-others work. In other cases, participants were making comments on examples prepared by Ian Cressie. Typical exercise was, for example: a short RA is given to students who have to write a missing abstract respecting the rules and functions of an abstract.

RA is like a cook-book! Be specific and provide all necessary detail

Most of the rules mentioned in this article were agreed by the majority of participants. We have also used results of previous investigations and inquiries of journal editors to support general conclusions. Nevertheless, some of the statements and principles reflect personal views and opinions and should not be confused with the cited literature. The listed rules and tips given here apply primarily to application-based sciences and RAs intended for publication in such journals.

### III. RESULTS

#### RA structure and style

Give summary results

A RA was first divided in number of article sections (further referred to as RAS) and elements (RAE). Participants agreed that the main article sections that are inevitable in any modern journal are, in this order: Title, Authors, Abstract, Introduction (I), Methodology (M), Results (R), Conclusions and Discussion (D) and References. These are the core body of RA. Additional listed RAS's were: Author-paper documentation, Keywords, Acknowledgements, Abbreviations and Appendices. The RAEs listed were: tables, figures (graphs, maps, diagrams, sketches etc.), equations, citations and footnotes and comments. The RAEs can come in different places in the RA, however tables and figures are more usual in Results section and equations and citations in Methodology and Introduction. All these RAS's and RAEs have their function and required style and should form a coherent unity. The functions of main RAS's and discussed rules of thumb are given in Table 2.

Compare results

Participants agreed that some RA, even with good data and interesting results, will be rejected if the style and format of the paper are not tailored for the audience. This agrees with the results of investigations among 116 editors (Gosden, 1992; Fig. 1), who identified following most frequent causes to reject an L2 author: unclear text, incoherent development of the topic in paragraphs and incorrect use of grammar. In addition, the participants analysed an exemplary flawed paper by unknown author and decided to reject it after some discussion. The list of reasons for rejection can be seen in Table 1.

Focus: put more focus on what should be emphasized

Table 1. Most important reasons for rejection of a RA.

Aspect	Reason for rejection
Topic	irrelevant topic or topic of local interest only
Newness	papers offers nothing new
Focus	topic, objectives and conclusions are not connected
Methodological steps	unclear and misleading argumentation; weak methodology or results
Style	unclear, unfocused and incoherent text
Data Quality	flawed design; insignificant sample number; preliminary findings only

**Table 2. Research Article Sections (RAS), main functions, preferred style and related rules of thumb.**

<b>RAS</b>	<b>Main functions</b>	<b>Preferred style</b>	<b>Rules of thumb</b>
<b>Title</b>	<ul style="list-style-type: none"> <li>- indicates content and main discoveries;</li> <li>- attracts the reader's attention;</li> </ul>	<ul style="list-style-type: none"> <li>- short and simple (7-10 words);</li> <li>- purposive (aims at specific audience);</li> </ul>	<ul style="list-style-type: none"> <li>- avoid complex grammar;</li> <li>- make it catchy!</li> <li>- avoid redundancy ("An investigation of...", "The analysis of...", "Effect of...", "Influence of...", "New method...");</li> </ul>
<b>Abstract</b>	<ul style="list-style-type: none"> <li>- reflects the main 'story' of the RA;</li> <li>- calls attention but avoids extra explanations;</li> </ul>	<ul style="list-style-type: none"> <li>- past (perfect) tense and passive voice(!)</li> <li>- short and concise sentences;</li> <li>- no citations, tables, equations, graphs etc.</li> </ul>	<ul style="list-style-type: none"> <li>- avoid introducing the topic;</li> <li>- explain: what was done, what was found and what are the main conclusions;</li> <li>- bring summary 'numbers';</li> </ul>
<b>Introduction</b>	<ul style="list-style-type: none"> <li>- introduces the topic and defines the terminology;</li> <li>- relates to the existing research;</li> <li>- indicated the focus of the paper and research objectives;</li> </ul>	<ul style="list-style-type: none"> <li>- simple tense for referring to established knowledge or past tense for literature review;</li> </ul>	<ul style="list-style-type: none"> <li>- use the state-of-the-art references;</li> <li>- follow the logical moves;</li> <li>- define your terminology to avoid confusion;</li> </ul>
<b>Methodology</b>	<ul style="list-style-type: none"> <li>- provides enough detail for competent researchers to repeat the experiment;</li> <li>- who, what, when, where, how and why?</li> </ul>	<ul style="list-style-type: none"> <li>- past tense but active voice(!);</li> <li>- correct and internationally recognised style and format (units, variables, materials etc.);</li> </ul>	<ul style="list-style-type: none"> <li>- mention everything you did that can make importance to the results;</li> <li>- don't cover your traces ("some data was ignored"), establish an authors voice ("we decided to ignore this data");</li> <li>- if a technique is familiar, only use its name (don't re-explain);</li> <li>- use simple(st) example to explain complex methodology;</li> </ul>
<b>Results</b>	<ul style="list-style-type: none"> <li>- gives summary results in graphics and numbers;</li> <li>- compares different 'treatments';</li> <li>- gives quantified proofs (statistical tests);</li> </ul>	<ul style="list-style-type: none"> <li>- past tense;</li> <li>- use tables and graphs and other illustrations;</li> </ul>	<ul style="list-style-type: none"> <li>- present summary data related to the RA objectives and not all research results;</li> <li>- give more emphasise on what should be emphasised - call attention to the most significant findings;</li> <li>- make clear separation between yours and others work;</li> </ul>
<b>Conclusions and Discussion</b>	<ul style="list-style-type: none"> <li>- answers research questions/objectives;</li> <li>- explains discrepancies and unexpected findings;</li> <li>- states importance of discoveries and future implications;</li> </ul>	<ul style="list-style-type: none"> <li>- simple or present tense (past tense if it is related to results);</li> <li>- allows scientific speculations (if necessary);</li> </ul>	<ul style="list-style-type: none"> <li>- do not recapitulate results but make statements;</li> <li>- make strong statements (avoid "It may be concluded..." style);</li> <li>- do not hide unexpected results - they can be the most important;</li> </ul>
<b>References</b>	<ul style="list-style-type: none"> <li>- gives list of related literature and information sources;</li> </ul>	<ul style="list-style-type: none"> <li>- depends on journal but authors/editors, year and title must be included;</li> </ul>	<ul style="list-style-type: none"> <li>- always cite the most accessible references;</li> <li>- cite primary source rather than review papers;</li> </ul>

## RA sub-structure

Participants also discovered that all RAS's can be separated in subsections or signposts, which can be arbitrary, but improve the structure of a RA. The recognized subsections were: research topic and definitions, research objectives (questions), methodological techniques, experimental set-up, object of the study (e.g. study area), main discoveries (analysed data), answers on research questions, explanation of the conclusions and further research and implications. The main RAS's are listed in a flow chart, showing main relations between different sections (Fig. 2). Fig. 3 shows the substructure of Introduction and Discussion RAS as the most important RAS's.

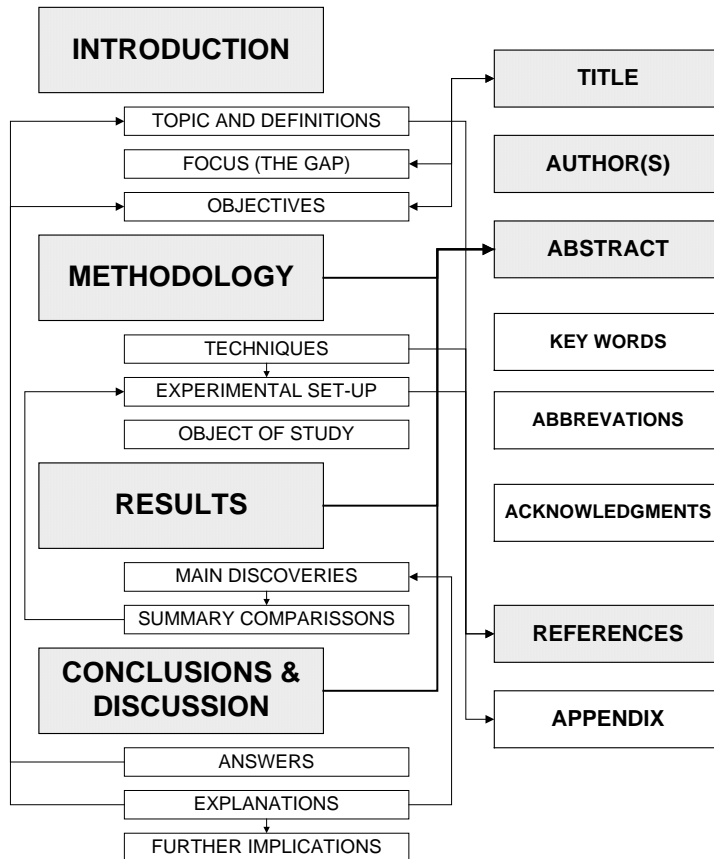


Fig. 2. Flow diagram: research article sections (shaded) and subsections, and their main relations.

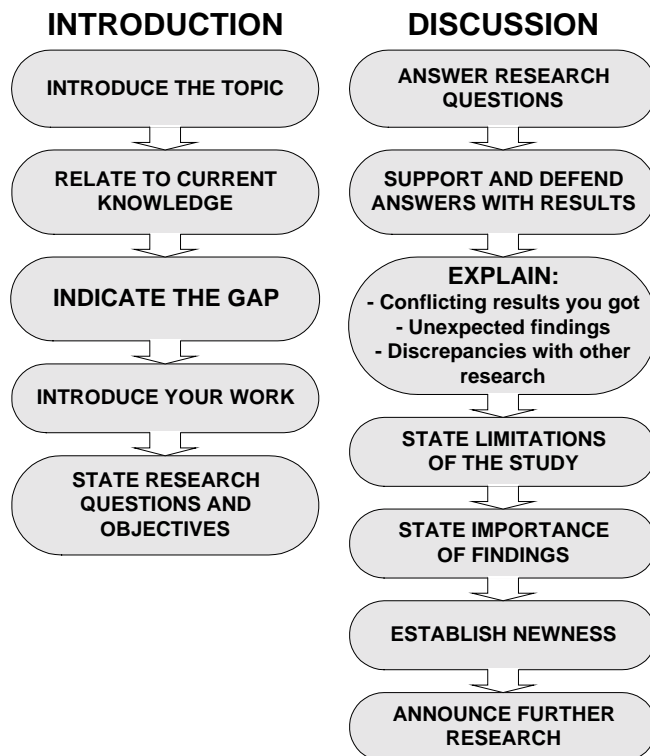


Fig. 3. Flow diagram: logical framework for RA sub-sections of Introduction and Discussion agreed by most of the participants.

#### IV. CONCLUSIONS AND DISCUSSION

What is the purpose of a RA and what makes it a good one, and who decides that it is a good RA? Are there rules for easier writing? If the main function of a RA is to transfer a new knowledge on a research topic, then a good paper is the one that is clear, coherent, focused, well argued and uses language that does not have ambiguous or equivocal meaning. However, it is not only the message that is important. The RA must have a well-defined structure and function in serve like a cook-book, so the others can reproduce and repeat explained experiments.

There are some rules that can make the writing and publishing of RAs 'easier'. Here, we summarised some 'golden' rules that should always be in the mind of an inexperienced researcher (Table 3). We put all these together to make a final list of some 40 logical steps, which can be find in the Appendix.

Answer  
research  
questions

Give  
summary  
conclusions

Table 3. Selected golden rules for easier publishing.

NAME	GOLDEN RULE
<b>TAKE A READER'S VIEW</b>	Write for your audience not for yourself.
<b>TELL A STORY</b>	Direct your RA but keep a clear focus in the paper and present only results that relate to it.
<b>BE YOURSELF</b>	Write like you speak and then revise and polish.
<b>MAKE IT SIMPLE</b>	Use simple(st) examples to explain complex methodology.
<b>MAKE IT CONCRETE</b>	Use concrete words and strong verbs, avoid noun clusters (more than three words), abstract and ambiguous words.
<b>MAKE IT SHORT</b>	Avoid redundancy, repetition and over-explanation of familiar techniques and terminology.
<b>TAKE RESPONSIBILITY</b>	Make a clear distinction between your work and that of others.
<b>MAKE STRONG STATEMENTS</b>	"We concluded... " instead of "It may be concluded... "
<b>BE SELF-CRITICAL</b>	Consider uncertainty of conclusions and their implications and acknowledge the work of others.

Although, it was assumed that the 'thicker' articles with wider range of vocabulary is preferable in the editors hands, the editors (and probably the readers) prefer simple, clear and coherent writing, rather than a fancy or complex, pseudo-scientific style. Also Funkhouser and Maccoby (1971) showed that the information gain is especially enhanced by the "use of examples", i.e. it helps a lot to use some non-science material, such as everyday life parallels, historical points, etc. On the other hand, some sections, such as Introduction and Discussion, have to intrigue readers and attract interest and should therefore not be over-simplified. For example, a mysterious title can catch readers' attention and will be easily remembered (e.g.: T.Y. Li and J. Yorke named their famous paper on chaos: "The period three means chaos"). Some sections require more skill and are more important. It is approximated that from all published journal RAs in the world, only less than 5% are read in detail. However, more than 50% of abstracts are read and so the quality of an abstracts is much more important (Gordon, 1983). Therefore, the abstract should present the 'story' of the RA in miniature and should be readable standalone.

Unexpected  
findings

Establish  
newness

The sub-structure of an Introduction was first described by Swales (1981) with so called "four moves". These latter on become three, the so-called CaRS model (Create-A-Research-Space) that are: establish a research "territory", establish a research "niche" and occupy the niche (Swales and Feak, 1994). In this case, participants concluded that especially the meso-structure of the Introduction and Discussion RAS should follow some logical flow of 'moves' (Fig. 2 & 3). The more structured and more exact is the paper, the easier it will get published. Each of RA elements has to fulfil its function in order to achieve this goal.

Explain dis-  
crepancies

However, this is not the whole story. A RA has to aim at specific audience/Journal, has to be novel and of high interest. Finally, one thing should be uppermost in researchers' minds: a good article is not only an article that has been published in a top journal - it is the reaction it causes that makes the difference. Therefore, a good article is the one that is read and cited (Publish or Perish!). In some cases, even a good paper will get rejected by the editors, i.e. journal. Unfortunately, sometimes the reasons can be subjective (maybe 1/3<sup>rd</sup> of all cases). Editors are often biased, they prefer one or other approach, academic level, gender... nation. These problems and issues such as fraud, plagiarism and ethics (Rossiter, 2001) were not discussed in this article but they certainly need attention.

A GOOD  
ARTICLE IS  
THE ONE  
THAT IS  
READ AND  
CITED!

Further  
research  
and  
implications

The searching, input and formatting of references, has been lately largely improved by the help of so called "information management tools" (Endnote, ProCite etc.). In addition, the role of companies involved in 'sorting' and 'filtering', such as Institute for Scientific Information (ISI), will increase. In future, we can expect more structured guidelines for writing a RA (templates?). The RA will also probably support multimedia (animations, sound recordings), which will improve communication between the readers/users and authors. These innovations will inevitably require require some new rules of thumb.

### Acknowledgements

We would like to thank Ian Cressie for their course and materials, which are of high importance for L2 PhD students. We also thank PhD student Jose L.C. Santos and Dr. David G. Rossiter for reading the text and giving us suggestions.

### V. REFERENCES

- Ackles, N., 1996. Naming a paper, ESL Center, University of Washington, Washington.
- ASA-CSA-SSSA, 1998. Publications Handbook and Style Manual. <http://www.asa-cssa-sssa.org/style98/>, 145 pp.
- Council of Biology Editors (CBE) (Editor), 1994. Scientific style and format. Cambridge University Press, Cambridge, 825 pp.
- Cressie, I., 2002. Writing & Editing Course, Lecture notes for ITC students. Enschede, pp. 120.
- Day, R.A. (Editor), 1994. How to write and publish a scientific paper. Oryx Pr., Phoenix, 223 pp.
- Funkhouser, G. R. and Maccoby, N., 1971. Communicating Specialized Science Information to a Lay Audience. *The Journal of Communication*, 21: 58.
- Gopen, G.D. and Swan, J.A., 1990. The Science of Scientific Writing. *American Scientist*, 78: 550-558.
- Gordon, M., 1983. Running a refereeing system. Primary Communications Research Centre, Leicester.
- Gosden, H., 1992. Research Writing and NNSs: From the Editors. *Journal of Second Language Writing*, 1(2): 123-139.

- Kirman, J., 1992. *Good style: writing for science and technology*. E. & F.N. Spon, London, 221 pp.
- McPhee, L., 2001. Teaching the Research Article Introduction, First EATAW Conference: Teaching Academic Writing Across Europe, Groningen.
- O'Conner, M. and Woodford, F.P., 1976. *Writing scientific papers in English*. Elsevier, Amsterdam, 108 pp.
- Prince, A., Blicblau, A.S. and Soesatyo, B., 1999. Implicit actions and explicit outcomes: cultural-academic interactions in writing journal research articles, AARE-NZARE. Swinburne University of Technology, pp. 8.
- Rossiter, D.G., 2001. Preparation for MSc Thesis Research. ITC, Enschede, <http://www.itc.nl/~rossiter/>, pp. 28.
- Swales, J., 1981. *Aspects of Article Introductions*. ESP Research Report No.1, University of Aston, Aston, UK.
- Swales, J.M. and Feak, C., 1994. *Academic Writing for Graduate Students*. Ann Arbor, the University of Michigan Press.
- Trelease, S.F., 1958. *How to write scientific and technical papers*. Williams and Wilkens, Baltimore, 185 pp.



## VI. APPENDIX

MAKE DRAFT	STEP 1	Make a working <b>title</b>	Put it all together:  writing a RA in 40 STEPS!
	STEP 2	Introduce the <b>topic</b> and define terminology	
	STEP 3	Emphasize why is the topic important	
	STEP 4	Relate to <b>current knowledge</b> : what's been done	
	STEP 5	Indicate the <b>gap</b> : what need's to be done?	
	STEP 6	Pose research <b>questions</b>	
	STEP 7	Give purpose and <b>objectives</b>	
	STEP 8	List methodological <b>steps</b>	
	STEP 9	Explain <b>theory</b> behind the methodology used	
	STEP 10	Describe <b>experimental set-up</b>	
	STEP 11	Describe <b>object</b> of the study (technical details)	
	STEP 12	Give summary <b>results</b>	
	STEP 13	Compare different results	
	STEP 14	Focus on main <b>discoveries</b>	
	STEP 15	Answer research questions ( <b>conclusions</b> )	
	STEP 16	Support and defend <b>answers</b>	
	STEP 17	Explain conflicting results, unexpected findings and <b>discrepancies</b> with other research	
	STEP 18	State <b>limitations</b> of the study	
	STEP 19	State importance of findings	
	STEP 20	Establish <b>newness</b>	
	STEP 21	Announce <b>further research</b>	
	STEP 22	ABSTRACT: what was done, what was found and what are the main conclusions	
REVISE	STEP 23	Is the title clear and does it reflect the content and main findings?	
	STEP 24	Are key terms clear and familiar?	
	STEP 25	Are the objectives clear and relevant to the audience?	
	STEP 26	Are all variables, techniques and materials listed, explained and linked to existing knowledge - are the results reproducible?	
	STEP 27	Are all results and comparisons relevant to the posed questions/objectives?	
	STEP 28	Do some statements and findings repeat in the text, tables of figures?	
	STEP 29	Do the main conclusions reflect the posed questions?	
	STEP 30	Will the main findings be unacceptable by the scientific community?	
	STEP 31	Is the text coherent, clear and focused on a specific problem/topic?	
	STEP 32	Is the abstract readable standalone (does it reflects the main story)?	
POLISH	STEP 33	Are proper tenses and voices used (active and passive)?	
	STEP 34	Are all equations mathematically correct and explained in the text?	
	STEP 35	Are all abbreviations explained?	
	STEP 36	Reconsider (avoid) using of words "very", "better", "may", "appears", "more", "convinced", "impression" in the text.	
	STEP 37	Are all abbreviations, measurement units, variables and techniques internationally recognised (IS)?	
	STEP 38	Are all figures/tables relevant and of good quality?	
	STEP 39	Are all figures, tables and equations listed and mentioned in the text?	
	STEP 40	Are all references relevant, up to date and accessible?	