Editorials

Publishing Scientific Articles with Special Reference to LCA and Related Topics *

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1 A Short History of Scientific Publishing

Modern science was born in Europe at the end of the 16th and early 17th Century for unknown reasons and during a terrible time. The glorious Renaissance was over and religious fundamentalism, as we would say today, and the torture and public burning of so-called witches, was at its peak.

In contrast to the medieval science, which strongly relied on authorities (above all Aristoteles) and secretiveness, modern science is critical and non-religious (not antireligious; most pioneers believed in God and adhered to one of the Christian churches, e.g. Galilei, Kepler and Newton), experimental and empirical [1]. Theories have to be based on experiments, observations and mathematics, not on metaphysical concepts.

Scientific results were published in the form of books. The informal communication between scientists was performed using letters – until the advent of the E-mail1. It is interesting to note that the than relatively young national languages started to replace the scholastic Latin in order to reach also the educated laypeople:

- Descartes: Latin + French
- Galilei: Latin + (Toscan) Italian
- Bacon, Newton: Latin + English
- Kepler: Latin + German (in popular publications only)

Most scientific pioneers of the 16th Century used Latin together with their native language. The situation is similar today: English, the Latin of our time, is preferred for international use and the national languages for the educated public at home or for topics of only regional interest.

The age of enlightenment, essentially the 18th Century, brought the scientific societies and the first scientific journals published by these 'academies'. The oldest scientific academies go back to the 17th Century, such as the 'accademia dei lyncei', Rome 1603 (Galileo Galilei was a member of this oldest scientific society), the 'royal society', London 1660, and the 'académie royale des sciences', Paris 16662. The journals slowly started to replace books as the main medium for the communication of original research, a process which continued in the 19th Century and is nearly complete today1. The typical article in natural science is concise, as opposed to most works of social sciences and humanities4. This split can still be observed today.

The material basis of this new way of publishing was the invention of printing with movable letters around 1450 by Johannes Gutenberg3 [2]. The importance of this invention cannot be overestimated. It replaced the – beautiful, but expensive and rare – hand-written books. In the beginning, the printing of books was under control of the catholic church, but this control slowly vanished under the influence of the Protestant churches and the free cities, e.g. Basel and Amsterdam. There is a theory that printing, as the first modern communication technology, triggered the social revolution of the modern times [2]. I think that this may also be true for the advent of modern science, at least it was a decisive factor for the break-through of modern science and made the broad distribution of new ideas and knowledge possible.

2 The Importance of Publishing, Philosophical Background

- The purpose of the prescientific publishing was to hide the essential points (e.g. how exactly to make gold)
- Modern science and publishing requires enough information to repeat experiments and to fully understand theories
- Falsification has to be possible in principle (Popper)
- Scientific fraud can be detected soon

There are other aspects of publishing which are related to epistemology, or: how can we find scientific truth? The old 'science' of the medieval age and prescientific publishing tried to hide the essential points, in a way similar to the modern patent literature. Such a behaviour is clearly unscientific. Modern science publishing requires enough details to allow the repetition of experiments and to fully understand theories.

According to Karl Popper [3], the falsification of hypotheses and theories has to be possible if they are to be scientific. This is an extraordinary insight into the nature of science and is complemented rather than disproved by other,

* This paper is based on a lecture presented at the PhD course: Bridging Environmental and Economic Assessments for Decision Support, Aalborg University (Denmark) September 15–20, 2006 [17]
1 Of course, E-mails can be considered as a kind of electronically transmitted letter; the speed of communication is paid, however, by an evident loss in style and carefulness in the preparation of this type of ephemeral document.
2 Preceded by an earlier (ca. 1640), loose circle of scientists and philosophers around Pascal and Descartes.
3 It is increasingly challenged, however, by direct publication in the internet.
4 In the German language, which is clearer in this respect, since Wissenschaft ('science') is divided into Naturwissenschaft (natural science) and Geisteswissenschaft (soft or humane sciences, although there is no simple translation for the latter term in English.
5 The art of printing has been known in China and South Korea since the 8th Century [2] but, in contrast to Europe, it did not cause a social revolution to occur there. Movable letters had been invented in Korea at about the same time as in Europe [2].
more sociological theories of modern science (e.g. by Thomas Kuhn [4]).

A more practical aspect of detailed publications is that scientific fraud can be detected rapidly. There are plenty of recent examples, especially in the modern, often overestimated fields of 'event- and show business' science.

3 The Special Role of LCA and Similar Assessment Tools: Can LCAs be falsified?

To conclude this historical-philosophical introduction with a provoking question: can LCA studies be falsified? Strictly following Popper [3], this means: is LCA an exact science? I would say, partly yes. Especially the inventory can be falsified, if the rules are taken into account.

But there are problems:

- Objectivity versus value choices
- Allocation, cut-off rules
- Choice of impact categories and indicator models
- Midpoint versus endpoint modelling

How to make LCA as scientific as possible?

A pragmatic solution for LCA – but not for related unstandardised methods – is strict adherence to the ISO standards of the 14040 series [5,6]. This makes different studies better comparable. It is said, however, in ISO 14040 (old [5a] and new [6a]) that, to a large extent, a specific study is determined by the first component of 'goal and scoping'. Only if goal and scoping is compatible, can two studies be compared? The 2nd and 3rd component [5b,c,6b], LCI and LCIA, have to be done according to the rules laid down in the first component.

The fourth component, Interpretation [5d,6b], is also important with regard to the scientific status of a particular LCA study: this is the place to critically discuss the mostly comparative results obtained and to estimate their uncertainty.

A critical review according to ISO 14040 [5a,6a] and 14044 [6b] further improves a study, removes serious errors and makes deceiving by means of comparative LCA studies much more difficult [7]. In this connection, it should be mentioned that the SETAC 'Code of Practice' of 1993 [8] and the following – now superseded – 'old' ISO standards [5] were already written under the impression of a considerable misuse of the method for marketing purposes in the late 1980s. These 'proto-LCAs' [9] were similar to modern LCIs and often contained a rudimentary impact assessment, the methods used by the individual research groups, however, varied considerably. The standards are therefore restrictive out of past experience. According to the revised ISO standards [6], an LCA study containing comparative assertions intended to be made public shall be reviewed according to the panel method with at least 3 panellists. The strong wording ('shall') indicates, how important this issue has been to the authors of the standards and that they did neither trust the objectivity of LCA, nor the honesty of the commissioners and practitioners.

Finally, the publication in a peer-reviewed journal constitutes a further hurdle against misuse of the method. Unfortunately, full publication of the data is often not possible due to confidentiality issues. The critical reviewers according to ISO have to ask for the data and to do plausibility judgments, compare with their own experience, etc. Of course, major faults in the main structure are more easy to recognize than small errors in the data set. The peer reviewers of the journals cannot ask for the full details due to restrictions in time and confidentiality; they have to rely on the results of the study review (if there were any!) and on their experience. They can ask for details in doubtful cases, however, and reject the paper if no satisfactory answer is given by the author(s). Furthermore, methodological details, references, etc. reveal scientific quality or inadequacy of a paper. In that way, the referees and editors determine from day to day what 'scientific' means in a certain field. This fine-tuning may, in the long run, be equally important for the development of the method as the overarching concept of finding scientific truth [3,4], especially in borderline cases like LCA and other assessment tools, where subjectivity cannot be fully avoided [10].

4 Where to Publish LCAs?

4.1 Survey

Presently, there are four journals publishing LCA-studies on a regular basis:

- The International Journal of Life Cycle Assessment (ecomed)
- Journal of Industrial Ecology (MIT Press)
- Journal of Cleaner Production (Elsevier)
- Integrated Environmental Assessment and Management, IEAM (SETAC Press)

In addition, special case studies can be published in journals dealing with the product group studied. For instance, the monumental ECOSOL6 LCI-study of surfactants used in the manufacture of detergents has been fully published in a series of papers in 'Tenside, Surfactants, Detergents', including the report by the critical review panel [11]. In fact, this kind of publishing case studies is an excellent idea, since these journals are read by those people interested in the product group assessed!

Int J LCA is placed on the top of the list since it is the only journal devoted entirely to LCA [12] and closely related concepts like Life Cycle Management (LCM) [13]. Int J LCA is also the official journal of several national LCA-Societies and the associate journal of the UNEP/SETAC Life Cycle Initiative.

J Industrial Ecology covers a much broader topic, but LCA is perhaps the single most important method used, together with Material Flow Analysis (MFA). This Journal also accepts long and comprehensive articles. The Editor-in-Chief is Reid Lifset. It is also the official journal of the Society for Industrial Ecology (SIE).

LCA is the main topic of one section in J Cleaner Production. Former LCA section editors were Kim Christensen and Tomas Ekvall.

*ECOSOL is a sector group of CEFIC, the European roof organization of the national chemical industry associations; this group, composed by the main European surfactant producers, acted as the commissioner and data-provider of the LCI study performed by Franklin Ass., Prairie Village, Kansas, USA.