



Building a library of chemistry education volumes

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Keith S. Taber 

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Indicators of mature research fields

There are a number of markers of research fields (Good, 2000; Fensham, 2004). In particular, a research field requires a body of researchers who are working in what is recognised as a distinct area of enquiry, and who themselves associate their work with that field. These scholars should be spread across more than one institution, and major research fields tend to involve an international group of scholars. Other markers include journals and conferences dedicated, and designated, to the field – which tend to appear once there is a sufficient cadre of researchers who recognise that there is a field, and chose to locate their work within that field.

Recognition is important here as a research field is a social phenomenon. Most scientists would consider that natural objects and classes exist independently of recognition (even if there are well respected and well-explored philosophical positions which would suggest other ways of thinking). So chemists have no trouble considering that oxygen existed long before the Lavoisiers developed their chemical theory, and scientists are happy to explain a major discontinuity in the evolution of the earth's atmosphere as occurring when, as a result

of biotic activity, oxygen levels become significant. We can recognise the presence and action of oxygen ions before any person had a conception of oxygen.

The same cannot be said of a research field. Chemistry Education only gave rise to a research field ('CER', Chemistry Education Research) when enough people involved in activities they considered as research in chemistry education themselves acknowledged the existence of a community of scholars sharing activity in this area of work. There was no doubt some research and scholarship related to the teaching and learning of chemistry predating the appearance of CER-as-a-field that would, had it been carried out today, be considered part of the CER field, but which was not at the time understood that way.

As one example, a research report published in 1930 (Parr and Spencer) gives an account of an attempt to explore, within the topic of the chemistry of calcium, whether students learn more by undertaking practical laboratory work before or after the teacher has presented the theoretical background (*i.e.*, either using practical work to motivate the learning of theory, or alternatively to demonstrate previously taught ideas). The research concerns an educational question, *i.e.*, about pedagogy; is undertaken within the context of chemistry school teaching and learning; and was published in a journal that would now be

considered a major outlet for work in CER. We can categorise and claim such work as CER, but should not in retrospect claim it was part of a field that had not yet evolved. (Perhaps there is a loose parallel here with how oxygen was able to act chemically long before it could be considered to be an object of study in chemistry.)

Today there is definitely a field of CER, which overlaps with some other fields (such as the broader field of science education research, SER), that in places blends into other fields (such as biochemistry education research), and shares interests with other cognate fields (such as physics education research, in – for example – considering how learners understand core scientific concepts such as energy across disciplinary lines). That is, there is a community of scholars who (i) consider themselves CER researchers, (ii) see (at least some of) their work as falling within CER, and (iii) actively seek to present at specific CER meetings and/or in recognised CER publication outlets.

There are other indicators of a field. Some academics are now appointed to lectureships, even chairs, associated with research in CER: *i.e.*, lecturer in chemistry education, professor of chemistry education. There are research groups who present themselves as working within CER. Applications for promotion within universities may now identify CER as an applicant's core area of research activity, such that the relevant promotions committees specifically seek

Science Education Centre, University of Cambridge,
Faculty of Education, 184 Hills Road, Cambridge CB2
8PQ, UK. E-mail: kst24@cam.ac.uk

external evaluators from within the CER community as having the most appropriate expertise for judging scholarly achievement and potential of such academics.

A field as a focus for scholarly volumes

One indicator of the growing maturity of a field is the presence of scholarly volumes clearly located within the field. This is one area where CER is less well established than some other fields within education (or indeed chemistry). At the time I was undertaking my doctoral work (about student learning in a chemistry concept area) I would likely have primarily seen this work as SER undertaken within a chemistry teaching topic. My project could be located within a well established research programme exploring the nature and contingencies of student learning in a wide range of science topics (Taber, 2009) – what is often called ‘constructivism’ in science education. Much of this work was published in SER journals, and there was a range of commonly consulted books summarising aspects of this work (Driver, 1983; Driver *et al.*, 1985, 1994; Osborne and Freyberg, 1985; Black and Lucas, 1993).

At this time I came across fewer scholarly books that were specifically focused on chemistry learning and teaching. An exception would be Herron's (1996) influential book about chemistry teaching, which whilst aimed at teachers was clearly the outcome of extensive scholarly work. Herron's volume was published by the American Chemical Society, and the Royal Society of Chemistry also produced research-informed volumes to inform teaching, although these were often sponsored by the Society's education department, and not primarily seen as commercial products. So volumes produced by the annual appointment of a Teacher Fellow (*e.g.*, Taber, 2002) were distributed to schools and colleges in the UK and the Republic of Ireland at the Society's expense.

Scholarly books on chemistry education

Although such volumes about chemistry teaching were often of interest to researchers, they targeted teachers as the main readership group. A notable event then was the

publication of “*Chemical Education: Research-based Practice*” (Gilbert *et al.*, 2002), not only because it was clearly aimed at the research community (Gilbert *et al.*, 2004), but because it was not published by a specialised Chemistry publisher, but rather by a major general academic publishing house, Kluwer Academic Publishers (now part of Springer Nature). In recent years, books of this kind have begun to appear with more regularity.

Some such books, akin to that of Gilbert and colleagues, look to survey the field (Garcia-Martinez and Serrano-Torregrosa, 2015). Others look at central aspects of teaching and learning chemistry, such as Gilbert and Treagust's (2009) volume on ‘Multiple Representation in Chemical Education’. There have been volumes specifically looking to support the development of researchers in CER (Bodner and Orgill, 2007; Bunce and Cole, 2008; Bunce and Cole, 2014). Other books explore specific aspects of work in chemistry education, such as the affective domain (Kahveci and Orgill, 2015) or pedagogy (Barke, 2006; Devetak and Glazar, 2014) or approaches to curriculum (Eilks and Hofstein, 2015).

A scholarly book series devoted to chemistry education

A further indicator of the increasing maturity of a field is the establishment of book series. There are for example a range of book series in science education. Springer publish a number of book series on science education around foci such as models and modelling in science education; cultural studies of science education; and educational aspects of philosophy and history of science. Routledge have a series on teaching and learning in science. Sense Publishers have a series on new directions in mathematics and science education, as well as a series on cultural and historical perspectives on science education. As these examples suggest science education is considered a sufficiently developed scholarly field to not only support markets for individual volumes, but also themed series within areas of work in the field of SER.

Clearly science education is more inclusive than chemistry education, as well as

being longer established as an identifiable international area of research and scholarship. However, CER has been growing in terms of the number of active community members, the diversity of national contexts in which CER is occurring, and the range of specific research programmes or themes attracting attention. Given this, there is a large and growing readership for books from within the CER field, and it seems likely that the frequency with which books with a strong CER focus will be published is set to increase over coming years.

The RSC has announced its own book series focused on CER:

“Books in this series review developments in areas of chemistry education internationally or report on a single educational context where the work has clear international significance; cover formal education, informal education, teacher education/development or public understanding of chemistry; and cover innovations in chemical education practice where suitable evidence of research-based evaluation is included. Topics covered will include approaches to teaching chemistry and chemistry topics; the use of technology in chemistry teaching and learning; assessment of learning in chemistry education; chemistry in the curriculum; chemistry teacher preparation and development; initiatives to improve public understanding of chemistry; and developments in research methodology as applied in chemistry education.”

<http://pubs.rsc.org/bookshop/collections/series?issn=2056-9335> (accessed 2017-09-11)

The RSC *Advances in Chemistry Education* series sets out to provide a home for volumes that make substantive contributions to the CER community through research and scholarship. Books in the series will provide research-informed guidance accessible to teachers, but will also be a key mechanism for encouraging dialogue among scholars active in the field. In this respect the RSC *Advances in Chemistry Education* series will complement CERP (*Chemistry Education Research and Practice*).

Qualities of a scholarly book

This raises the issue of how such books will make a contribution that is distinct

from the research journal, and this in part links to the grain size of research within a field. The research article tends to offer a discrete quantum of advance of knowledge (whether as research outcomes, or as a new perspective), published as soon as possible, so to communicate new findings or ideas with others in the community. Research articles build upon each other (and sometimes challenge what has gone before), and contribute to the organic growth of a research area. However contributions within a research programme will be distributed over time and (usually) outputs – and this may include journals with very different styles and norms (Taber, 2009). A book offers the chance for a coherent, less urgent, but more substantive and reflective contribution: a contribution that extends beyond the accounts of a single study, and therefore offers more scope for engagement with a reader and for the development of a perspective or line of argument – or, indeed, the juxtaposition of alternatives when these remain under active consideration within the field.

As the first major book series in chemistry education, the *RSC Advances in Chemistry Education* series is expected to incorporate different forms of contribution to the field. The series will include both monographs where an author develops a theme at book length, and edited volumes where specialist editors curate a collection of contributions on a theme. Whilst publication decisions necessarily have to take into account the commercial viability of a proposed volume in terms of the likely level of interest among potential readers, proposals will be subject to peer review by experts in the field to evaluate their likely scholarly contribution.

Different approaches to composing scholarly volumes

Book authors may describe the development of a programme of research over a series of studies (that would often have individually been previously reported across a range of journal articles

extended in time) with the perspective of hindsight and a level of synthesis that would have been absent at the time of completing the individual studies. Arguably, such accounts have potential to reflect science-in-the-making (Shapin, 1992) or science in action (Latour, 1987) much better than the often necessarily sanitised accounts reflected in research reports of individual studies (Medawar, 1963/1990). As well as potentially making for a good read, such narratives may also be very useful in giving new researchers a feel for the programmatic, and sometimes highly constrained – or even compromised – nature of authentic research. Other authored contributions to the series will offer reviews and syntheses of areas of research. These may reflect in purpose and approach the review (or perhaps perspective) articles published in *CERP*, but where the topic deserves, and benefits from, a much more detailed treatment than is feasible in a single article.

The other type of contribution to the new series will be edited volumes, which offer editors the chance to engage a team of specialist authors to make discrete contributions on a single overall theme within CER. This could be reports of related studies from distinct researchers or research groups but falling within a common overall research programme – that is where the different researchers share guiding commitments for their work (Lakatos, 1970), such as assumptions about the nature of what is being researched, or about methodologies appropriate to the research focus and epistemological challenges of that kind of study (Taber, 2014). The editors can ensure that the studies reported are described in a coordinated and coherent way, and collectively shaped to summarise the overall consequences and impact of the work.

Other edited volumes may curate a selection of distinct contributions on a theme that do not offer such coherence. This is indicated in areas where there are clear on-going scholarly disagreements about how to conceptualise phenomena, and/or the most useful theoretical perspectives, and so, consequently, the most insightful research approaches. Here the

editors can help the reader by bringing together contributions to juxtapose the various positions, and indeed advance the debate by seeking to provide a means to facilitate dialogue within the volume. This could be through allowing opportunity for authors to comment on, and respond to, each other, or by the editors offering their own commentaries and syntheses.

In some respects edited volumes of this kind reflect the idea of a journal theme issue. However a theme issue has an open call, and admits articles purely on criteria of relevance, originality and quality, and given the timescale of journal publication the guest editors of a journal theme issue often have only a modest opportunity to shape an editorial around contributing articles. The former point reflects a general feature of research journals in that they tend to largely follow the field. The extent to which journal editors and boards should (or should be permitted to) actively seek to shape the development of a research field is open to debate. Clearly editorial boards – of journals or book series – have some responsibility for supporting the development of a field, but it is a matter of opinion at what point encouragement of innovation comes to be seen as bias and leadership of a field gives way to misuse of influence.

Generally, however, journals are responsive rather than proactive. The themes of articles that appear in research journals over time are primarily determined by what members of the community chose to work on and write about. That is a key feature of the academic freedom (albeit ‘freedom’ inevitably modified by funding decisions, appointment and promotion decisions, *etc.*) of scholars. This means that the direction of a field is never centrally controlled (*cf.*, Josephson, 1992), but retains a somewhat democratic character, such that all active researchers in a field can influence its direction. Guest editors can attempt to provide balance in theme issues of journals by encouraging a range of colleagues to write, but the open nature of submissions limits editorial control (assuming editors seek to apply scope and reviewing procedures fairly, which

is something authors and readers have a right to expect).

Editors of a book are able to do much more to seek balance by determining the shape of their volume and ensuring the spread of contributions gives a good coverage of the topic. They may work purely by direct invitation, or they may offer a call for potential contributions through their professional networks. Ultimately, however, it is up to the editors which contributions they wish to include in a book proposal. Peer review of proposals may point out any apparent gaps in the plan for a volume, or perceived limitations in fitting expected chapters within a coherent theme, but does not require editors to 'unbalance' their volumes by accepting any and all relevant, high quality, contributions that are offered (in the manner in which journals accept any and all submissions that meet their criteria). An edited book is then a different kind of beast to a themed journal issue – again offering the potential for a more reflective and considered approach that sums up – or even puts a particular slant on – the current state of work around a topic, rather than simply reflecting the most recent work.

It is possible for other formats to be proposed, and to be considered for recommendation by the series editors and their international panel of advisors. The criteria by which proposals will be evaluated are those expected of a scholarly series: volumes must be substantially about chemistry education (*i.e.* aspects of the teaching and learning of chemistry, and related topics), must offer a substantive contribution in terms of original scholarship, and be of high academic quality. So as one example, it might be possible to propose a kind of Festschrift relating to a senior academic in the field, with various contributions highlighting different but related aspects of their contributions to CER.

Volumes within a CER book series could explore an approach to pedagogy applied across the teaching of chemistry, or review different perspectives on teaching and learning in a specific chemistry topic. Books could focus on particular educational levels, or on themes that cross those levels. Contributions may derive from one specific educational context, where the lessons

drawn are shown to be relevant to readers working internationally; or volumes may deliberately juxtapose work relating to particular foci from diverse national or cultural contexts. This approach could be employed to demonstrate similarities or differences: either to draw out commonalities found across teaching contexts (*cf.* Taber, 2013), or to highlight how contextual factors can impinge upon and influence teaching and learning (*cf.* Taber, 2012) even when the subject matter (chemistry) is itself largely considered culture-neutral.

The series has now been formally announced, and the first volumes for the series are being prepared. Potential authors or editors are invited to make contact with ideas or formal proposals. (Editors for the series are Profs. Avi Hofstein, Vicente Talanquer, and David Treagust, as well as myself.) It is expected that volumes will start to appearing in 2018. At that point there will be yet another visible indicator that CER is becoming a mature research field.

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