Three levels of chemistry educational research

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Manuscripts submitted for publication in this journal, as for most journals, are screened to check that they fit the remit of the journal, before they are sent out for peer review. Submissions that are not considered 'on topic' are politely rejected without referees being asked to review them for quality (Taber, 2012). Sometimes material is rejected at this initial editorial screening stage because it does not present a prima facie appearance of reporting research or scholarship (rather than, say, a purely descriptive account of a laboratory exercise). However, some submissions are declined because they are not considered to be sufficiently about chemistry education.

Material received for publication that is not considered to be on the topic of chemistry education sometimes offers an account of some area of chemistry. Presumably some authors feel that their particular take on some chemical content can comprise an original contribution to the field of chemistry education. Perhaps they are right: but if the authors have not systematically evaluated their proposed approach in an authentic teaching context; and/or there is no substantive scholarly argument for the educational merits and originality of the presentation grounded in the published literature on chemistry education, then there is no basis for reporting the work in a research journal.

Publishing in a specialist journal

In this editorial I wish to consider when submissions that clearly *do* report educational research and/or scholarship have a place in a specialist journal such as *Chemistry Education Research and Practice* rather than a more 'general' educational research journal. Chemistry is often said to be taught and learnt at three representational 'levels' (Johnstone, 1982; Taber, 2013). I suggest here that it is helpful to consider a three-category typology representing the 'levels' at which an educational study can be located in relation to a specialist sub-field, such as chemistry education. The typology is just a model, and it is not suggested that all manuscripts will unequivocally fit into one of the three categories, but rather that this might be a useful tool for authors considering whether a research report is best suited to a journal like *Chemistry Education Research and Practice* or a more general education journal.

Journal submissions can vary along a range of dimensions, but of particular interest here is the nature of *the focus of the submission, in relation to chemistry education research as a field*. In this regard, a simple three-category typology seems useful. The key question might be posed along the lines: in what sense does the submission report research and/or scholarship that is located *within* the field of chemistry education and so can be classed as *chemistry* education research (CER)?

The central concerns of education are teaching and learning (Pring, 2000), and the institutions and circumstances that impinge upon teaching and learning. This offers a wide range of foci for studies – including for example those undertaken from psychological, sociological, organisational and philosophical perspectives. Chemistry education is nested within the broader field of education, but clearly has a specific concern with the teaching and learning of *chemistry in particular*. So studies that fall within the field of chemistry education may reflect the diverse range of foci found more widely in education, *but* will be set in the more specific context of chemistry teaching and learning (CT&L). The question considered here is whether educational studies set within the context of CT&L should automatically be seen as part of the field of chemistry education: whether setting a study in a CT&L context is a sufficient, as well as a necessary, condition for contributing to the field of chemistry education. The argument here is that this is *not* sufficient, and this is why I am suggesting the three-level typology.

Three levels of research in CT&L contexts

My suggestion is that to a good approximation we may consider educational studies undertaken in the context of CT&L to fall into three categories that can be labelled as inherent, embedded and collateral CER (see Figure 1).

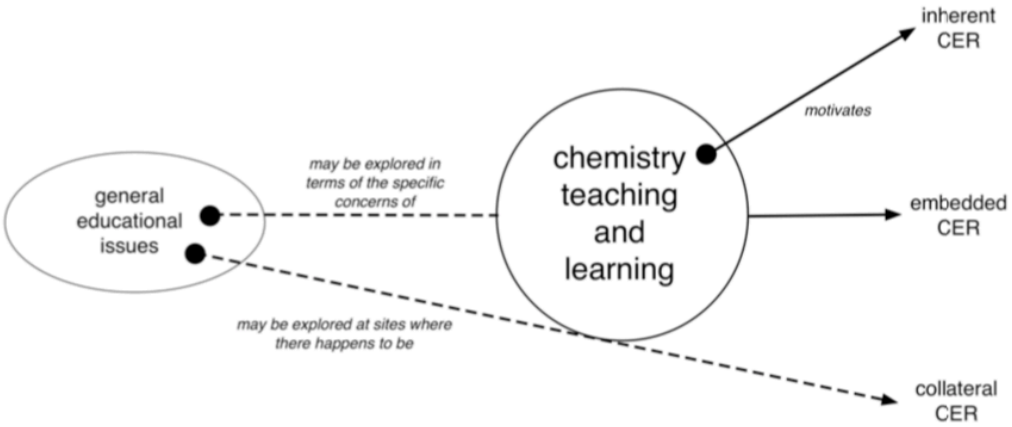

Figure 1. Three levels of Chemistry Education Research (CER)

This is an issue that arises from teaching and learning chemistry…

Inherent chemistry education research (ICER) has a focus that derives from issues that are intrinsic to teaching and learning chemistry. These issues may often have parallels in other curriculum subjects (particularly the other sciences), but are inherently linked to the nature and subject matter of chemistry as a discipline and teaching subject.

Sometimes such research may relate to foci that are clearly linked to specific aspects of CT&L: for example, students' learning about the three dimensional structure of organic molecules and how these structures are commonly represented in chemistry; or teaching that can facilitate better understanding of the chemical concept of 'substance' and how this relates to materials found in everyday life.

On other occasions there may be issues that are broader, but are particularly significant in teaching and learning chemistry. One example might be the relationship between submicroscopic models of the structure of matter and the observed properties of matter at the macroscopic scale. This is important in physics (e.g. understanding models of electrical current) and biology (e.g. understanding the specificity of enzymes), but is of particular importance in teaching and learning

chemistry where so much of the subject is framed in terms of theoretical models at the submicroscopic level providing explanations for observable properties.

Another example would be the 'model confusion' (Carr, 1984) so commonly experienced in learning chemistry. Again this is not entirely specific to chemistry, but in many topics (atomic and molecular structure, acids, oxidation, etc) students are offered an array of distinct - and often inconsistent - models to use as thinking tools as they make progress in the subject. These models are not necessarily seen as entirely supplanting each other as the student moves towards higher levels. So the same bond may be considered a polar bond for one purpose in Monday's class, but may be referred to as covalent the next day when a less sophisticated approach is deemed fit-for-purpose. Arguably, such multiplicity of (somewhat competing; somewhat complementary) models is intrinsic to learning about chemistry (Taber, 2010). Consequently, research into how students make sense of the array of complementary models presented in chemistry teaching can be considered to be something of particular importance to the field of CER, and so would be considered ICER in the typology.

We wanted to explore this in the context of chemistry learning…

The second category is labelled as embedded chemistry education research (ECER) because it concerns a focus that is extrinsic to chemistry education as a field, but has been conceptualised carefully within a CT&L context in a particular study. There are many legitimate topics within educational research which could be studied within the context of CT&L: student motivation; group-work; peer assessment; teacher questioning techniques, etc. The question then is whether studying such topics within the context of CT&L is sufficient to locate such studies within the specialist field of chemistry education. The suggestion here is that if a research question does not depend upon a CT&L context, then it does not motivate a study that can be considered within the specialist field of CER. So, for example, if a researcher was interested in the relative engagement of male and female students in discussion work in secondary level classes, and undertook data collection in a secondary school chemistry class, then the chemistry class could just be a convenient site for data collection rather than an essential element of the research design.

For such a study to be seen as ECER, and so within the field of chemistry education, there would have to be a deliberate and premeditated rationale for the significance of the work being undertaken in a *chemistry* class. A case would need to be made for the particular relevance of a CT&L context as part of the conceptualisation of the study. Perhaps, in this hypothetical case, it

might be argued that discussion work in chemistry has some special features due to the nature of socio-scientific issues considered in the subject; perhaps it might be argued that in a particular national context chemistry has traditionally been seen as more suited for males, and so the researcher wanted to see if this was reflected in the extent to which female students wished to, and felt confident enough to, contribute to discussion in chemistry classrooms. An argument would need to be made for a linkage between the general issue and *the specifics* of teaching and learning chemistry as part of the conceptual framework presented at the start of a paper; and this mooted linkage would then need to be revisited in the discussion of the results of the research in a submitted report of the study.

In this way, an issue that may be of wider interest in education, is embedded within what could be considered the proper particular concerns of the chemistry education community. I can illustrate this with an example related to some of my own work, and the notion of 'p-prims' or phenomenological primitives (diSessa, 1993) that derives from work in the learning sciences, and so is not specific to chemistry education. There is a vast literature on learners' ideas in science topics, especially those which are seen as inconsistent with the canonical ideas of science itself (Duit, 2009). The diverse evidence base about the nature and origin of these notions (Taber, 2009) seems to suggest that although some ideas elicited from learners may be sensibly considered to be alternative conceptions or conceptual frameworks (ideas that are well-established and which learners are explicitly aware of holding), learners also commonly present explanations and ideas that are in effect constructed in the act of answering a researcher's question, and that these responses may commonly draw upon spontaneously applied *implicit* knowledge elements that are quite different to alternative conceptions (not being available for direct introspection, for example). Such implicit knowledge elements have been labelled as p-prims, and have been characterised by extensive work carried out by Andrea diSessa in the context of physics learning contexts.

P-prims are not supposed to be subject-specific, but rather act as general-purpose cognitive elements that are activated whenever they seem to fit a perceived context. This theoretical perspective suggests that learners' p-prims channel their thinking across academic subjects, and so can lead to either canonical or alternative understandings. However, because the original work characterising them was largely carried out in the context of physics learning, this invites the question of whether the same set of p-prims would be found to be operating in other learning contexts, and so there is clearly scope for research that looks to test out this theory in the specific context of chemistry education.

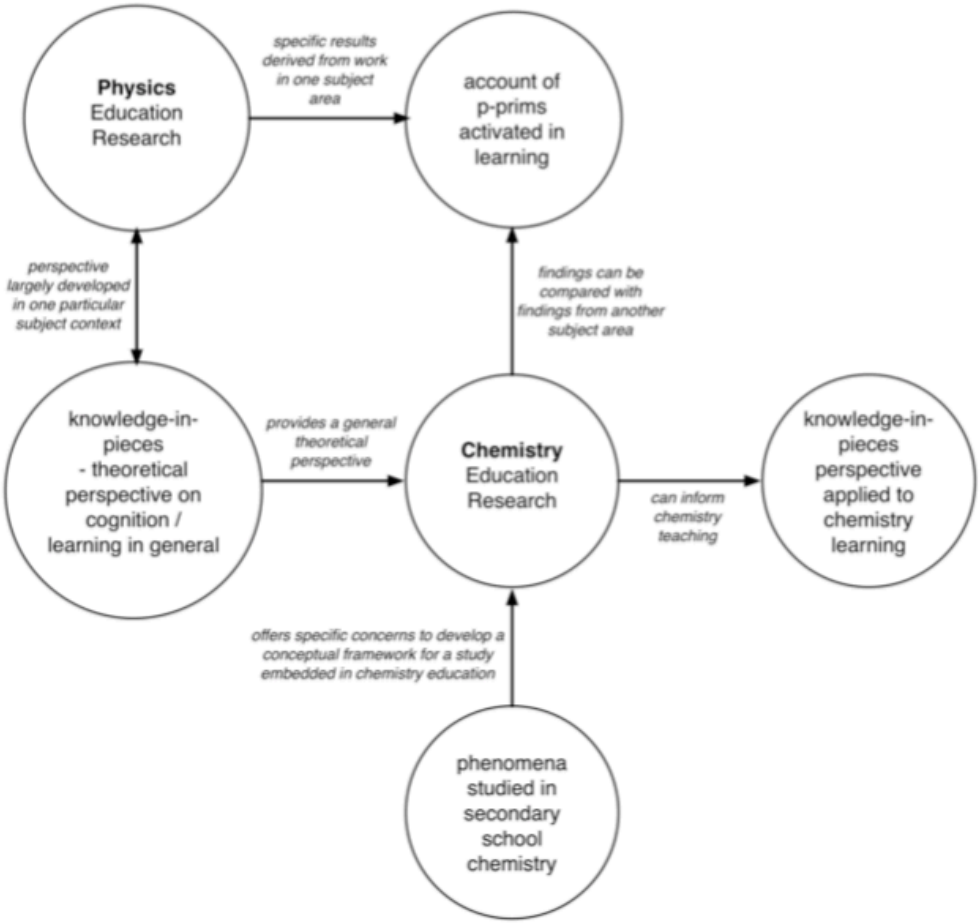

Figure 2: A theoretical perspective that is not intrinsic to chemistry education may be used as the basis of developing a conceptual framework for a study that *is* embedded in chemistry education

This was the basis of some work carried out by Alejandra García Franco who looked for p-prim type knowledge elements being applied by secondary age learners explaining a range of basic phenomena met in school chemistry (Taber & García Franco, 2010). The theoretical perspective, known as 'knowledge-in-pieces' (Smith, diSessa, & Roschelle, 1993), was not something intrinsic to teaching and learning chemistry, but García Franco's study embedded this general perspective within a specific CT&L context in exploring students' explanations of such phenomena as dissolving, mixing and chemical reactions (see Figure 2).

We chose a chemistry class…

So clearly research with foci external to the central interests of chemistry education can be linked with specific issues in teaching and learning chemistry, and so can be embedded within CER, and can lead to studies of particular interest to the chemistry education community. However, there are also many studies where there is a general educational focus, and the research questions do not make strong links with anything that is particular or intrinsic to CT&L, but which are carried out in CT&L contexts. As far as the researchers are concerned, the chemistry teaching and/or learning context provides a convenient and suitable - but not an essential - site for the study. In terms of the research questions and design, there would be nothing about the chemistry context that was integral to the study, and so in principle the same work could be carried out just as well in a mathematics class or a geography lesson for example.

In these cases the chemistry context is coincidental and so this is considered collateral chemistry education research (CCER) as the research runs alongside the CT&L without ever making a strong link to what might be special and particular about that teaching and learning context. The research may well be interesting and worthwhile as educational research, and may indeed offer insights of relevance to chemistry classrooms – but only because it is relevant to classrooms more widely.

The typology is presented in Table 1, which sets out how the core concerns of the three categories of study link to issues specific to teaching and learning chemistry.

Category	Relationship to CT&L	Notes
Inherent CER	Intrinsic	Concerns explored arise from the specific nature of teaching and learning chemistry as a curriculum subject.
Embedded CER	Extrinsic	Concerns explored arise from general issues in teaching and learning, but have been conceptualised within the specific context of teaching and learning chemistry.
Collateral CER	Coincidental	Concerns explored arise from and are conceptualised as general issues in teaching and learning, and chemistry teaching/learning simply provides a convenient context for data collection.

Table 1: A typology of research carried out in CT&L contexts

Publishing studies carried out in CT&L contexts

The purpose of highlighting this typology relates to the question of when a study is best reported in a specialised chemistry education journal such as *Chemistry Education Research and Practice*. Clearly work classed as ICER would be seen as centrally concerned with issues in teaching and learning chemistry and likely to be of particular interest to others working in chemistry education. Such studies would certainly fall within the remit of a specialised Chemistry Education journal (see Figure 3), and, indeed, could be considered to be too specialised for more general educational journals.

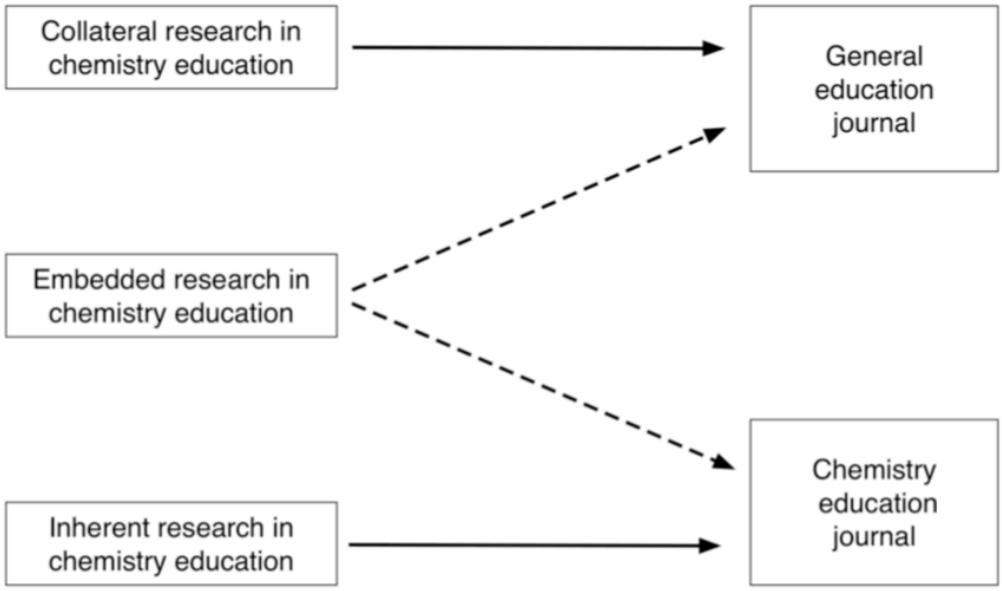

Figure 3: Publishing reports from three categories of research undertaken in the context of teaching and learning chemistry

Studies that are concerned with general educational issues that are not specific to teaching and learning chemistry are less obviously suited to a specialist journal, and this is where it becomes important to consider whether the general issue has been conceptualised in relation to the specifics of teaching and learning chemistry or not. Where authors have made a particular effort to motivate their study in relation to what is special about chemistry classrooms (i.e., ECER), then their work is likely to be considered suited to a specialist journal.

Arguably, authors of ECER studies may have a choice to make over whether to send such a study to a specialist journal (emphasising what is special about the subject specific teaching and learning

context) or a general education journal (setting out the particular context as simply a suitable context for the study, and emphasising the general features of the work over the subject specific ones). Perhaps a research programme where data is collected across a range of subject teaching and learning contexts might warrant reporting both in a general educational journal (where the subject contexts are seen as offering a diverse sample of teaching and learning contexts), and in subject specific journals where important nuances of the findings in the different particular contexts can be drawn out. García Franco's study referred to above was certainly embedded in chemistry education, but was reported in a journal concerned with learning processes in general. It was considered that the question of whether knowledge elements identified from physics education studies could be considered to apply in other curriculum areas was potentially of interest beyond the CER community.

It is less likely that studies concerned with general educational issues that are located in CT&L contexts without clear motivation (i.e., CCER), will be seen as suitable for a specialist journal such as *Chemistry Education Research and Practice*. So a paper that explores how learners in a chemistry classroom respond to formative assessment does not earn a place in a CER journal unless the conceptual framework and discussion of results draw out features of the study that are related to what might be particular about the kind of formative assessment offered in chemistry classrooms. Similarly, a study on the way learners organise and manage group work that happens to have been undertaken in a chemistry classroom is not automatically of particular interest to the field of CER.

The former hypothetical example might shift from CCER to ECER if the study looked in detail at the nature of the formative feedback offered in relation to the particular chemical subject matter being taught and learnt: but remains CCER if this is simply presented as background. Similarly, in the latter example, if the data collected on how students organise their group work were linked to the specifics of coordinating group practical work in the teaching laboratory it could indeed become considered as ECER, whereas if it is simply *reported* that the observations took place during chemistry practical work, it would remain as CCER.

Levelling decisions made by authors and editors

As suggested above, this typology is only meant as a model, and there is often room for judgement in assigning a particular manuscript to these categories. Individuals may differ in their views of what are inherent issues in CT&L; or how strongly foregrounded CT&L-specific issues have to be in ECER. Yet such considerations do have practical consequences for authors.

Authors are sometimes told that their submission to a journal is considered too specialised for a general journal, or indeed, to general for a specialist journal. I have even heard of a case where authors were initially asked to revise a submission for a journal, only to be told after the revision had been submitted and reviewed that the referees or editors belatedly decided the submission did not have enough specialist content to be suitable for that journal.

After a submission has been received by *Chemistry Education Research and Practice*, a decision is made about whether the paper does indeed report work which falls within the scope of the journal – if it has enough chemistry education content. Submissions reporting educational enquiry located in a CT&L context, but without appearing to be embedded in the scholarship and concerns of CER (and so seen as CCER), are politely refused.

Perhaps if the researcher is a chemistry educator, and they are following an interest in an important educational issue within the context of some CT&L, it may not occur to them that their work could be seen by others as only coincidentally located in chemistry education. A worse case scenario may be a study which is conceptualised in general educational terms (CCER) and so not considered suitable for a specialist journal, but seen as too provisional for publication in a general education journal because of the choice of research setting within a single curriculum area. In such a case a study may be judged (by different journals) as both too general *and yet* too specific for publication.

The purpose of this editorial is to highlight this issue, and suggest it is something potential authors need to consider at the outset of a research project. If a study is conceptualised purely in general educational terms, then locating it within a CT&L context will not be enough to make the study recognisable as a potential contribution to chemistry education. Reports of such (CCER) studies are unlikely to be suitable for consideration by *Chemistry Education Research and Practice*. However, the journal certainly welcomes submissions reporting studies where authors have successfully embedded the exploration of a more general issue within the specific scholarship and concerns of chemistry education (ECER); as well as studies directly motivated by concerns inherent to chemistry education (ICER).

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