12 Navigating from science into education research

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Introduction

The threshold into publishable education research for someone who is used to publishing disciplinary research in a STEM environment is non-trivial (Adendorff 2011). The purpose of this chapter is to provide something of a map. It will not provide a 'method' but rather give an explanation of the distinctions between science and social science. Not all education research is social science, but it is this aspect of education research that can appear to be a non-navigable wilderness to those who enter from a STEM discipline. The first part of the chapter is dedicated to a description of a philosophy called 'critical realism,' which offers a useful foundation from which we can view both research in science and in social science and thus show some of the similarities and distinctions between the two. This is followed by a brief discussion about Legitimation Code Theory (LCT). Finally, pointers are given on what is necessary to consider when undertaking a study enacting LCT.

Critical realism

The real, the actual and the empirical

Critical realism holds a realist ontology, whilst recognizing that knowledge of that reality is socially constructed. The 'realist ontology' means that the physical world is real and the mechanisms that account for change in the physical world are independent of humans. However, the physical world and humanity are such that we have a capacity to observe, interrogate and devise explanations for those mechanisms of change. This practice is what we call 'science.' The explanations of those mechanisms are, however, subject to two different kinds of limitations. The first limitation is that we can only describe or attempt to explain what we can observe. We do not know, and actually cannot know, how much of reality we can observe. Critical realism, therefore, divides that which is ontologically real into three realms (Figure 12.1): the real (the whole), the actual (where mechanisms actually operate) and the empirical (that which is observable by human beings). Thus, the scientific method as it is usually taught in undergraduate programmes is constrained

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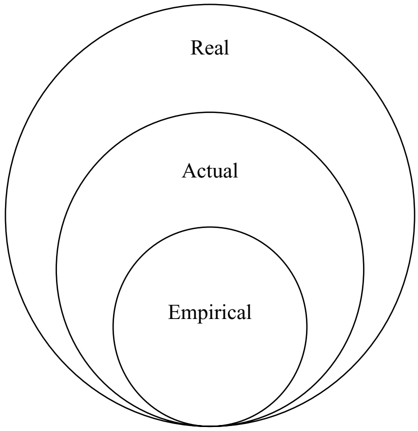

Figure 12.1 Nested relationship between the real, the actual and the empirical domains.

to the empirical (Bhaskar 1978). The second limitation is that the description or tested explanation given by science, the scientific concept, is often presented as a 'fact,' but there is a fundamental difference between the concept and the thing being described by the concept.

Two common errors made by some scientists are scientism and naïve realism. These are usually blind spots that are unconsciously fostered in our current dominant forms of science education and thus may be quite prevalent among academic scientists. 'Scientism' is the erroneous limitation of that which is knowable to that which is empirically accessible in the physical world. Rather than recognizing that science can only explain that which is observable. Thus it gives an inflated description of science and tends to overlook the value of a knowledge area which does not conform to the norms of scientific observation. 'Naïve realism' is the failure to make a distinction between that which is observable and the description of the thing observed. In other words, the scientific concept is conflated with the object of study.

It should be pointed out here that for many scientists, there may be some discrepancy between their espoused theoretical framework (the framework they say they hold) and their operational theoretical framework (the framework they actually use). Few scientists would argue against the part of critical realism thus far described. However, few scientists need to make the distinction between that which is described and that which is real in their research. For example, there is no need to make a distinction between the concept of molecules (the description) and the actual entities that are reacting in the flask (that which is real). As a result scientists often fail to make this distinction explicit in their teaching. Thus, whilst their espoused theoretical framework may align with critical realism, their operational theoretical framework may be one of naïve realism. The student is therefore exposed to implicit naïve realism, rather than the more sophisticated position that the academic claims they hold. This is not necessarily an issue, but it does hold the possibility that a student could graduate with a Bachelor of Science degree and not recognize that there is a distinction between the concept of the molecule and the entity in the flask. Within many scientific disciplines, the operational theoretical framework is simply assumed to be common within the discipline and therefore is not made explicit in the scientific literature. As a consequence, many scientists simply have no need to give it much thought (the unconscious blind spot alluded to above). This situation is exacerbated by the fact that many of the significant scientific theories taught at an undergraduate level have been established for decades and thus the contingency of scientific knowledge is not made visible.

The scientist as agent

The second aspect of critical realism that is important for the academic scientist who is dipping their toes into education research is more likely to require a conscious shift in perspective. We are used to thinking of the scientist as the neutral observer. For Bhaskar (1978), the scientist is an agent in the process. In *A Realist Theory of Science*, Bhaskar (1978) makes an argument for the open nature of the real domain. That is to say, the real world is always an open system. The practice of scientific research, in general, is the intentional closure of a system in order to investigate a particular mechanism – the scientific method. Thus, the scientist is not merely a passive observer but also an agent who actively closes a system in order to investigate a particular empirical phenomenon, of a particular actual event, caused by a particular mechanism or confluence of mechanisms. What makes science reproducible by different scientists in different parts of the world is the reality of the underlying mechanisms. Once the conditions of closure to investigate a specific mechanism or set of related mechanisms are adequately described (the experimental method), the experiment can reliably be expected to be reproducible by a second scientist. The understanding of the mechanisms is 'scientific knowledge' and is a product of society. It will thus be subject to influence by history and personal experience. Over time, this particularity of the first description will be refined as more data is brought to bear on the mechanism and as the science itself evolves. Nonetheless, the existing models and explanations of the mechanism (scientific knowledge) will profoundly influence the manner in which both the experiment is carried out and the way in which the data is interpreted.

It is probably helpful at this point in the discussion to pause and consider a particular example from your own field of research. I am a synthetic chemist, so a typical experiment in my field would be designing a reaction to form a specific product. Presuming the product has not been reported before, I will draw on various previously described reactions to design the new synthesis. I will also draw heavily on my experience of performing reactions. If I have a choice, I will choose a reaction I am familiar with over one I have never done before. Once the reaction has been designed, I will try it out and repeat several times until I am satisfied that it is reliably reproducible. Note that the design of the experiment is guided significantly by my own prior experience and my understanding of what methods can theoretically be brought to bear on this particular reaction.

In more general terms, then, the experiment once reported should be reproducible, but the design of the initial experiment is subject to variation based on the individual researcher and will be substantially influenced by the theoretical understanding of that researcher at that point in time. What makes science 'objective' is that real mechanisms are at work in a well-defined, closed system. The chemical reaction in the previous paragraph works because there is a real mechanism that is at work and which I have harnessed to create the molecule that I desire. If the system is sufficiently well described, it can be reproduced by another person in a different environment. Someone in Cairo could follow my description and should get the same product. The 'objectivity' is thus a product of the well-defined, closed system, not a personal quality of the scientist. Note though that the design of the first experiment to investigate the existence or nature of a particular mechanism will be subject to influence by the personal experience of the researcher. This is Bhaskar's point that scientists are not passive observers but rather active agents in the production of this activity called science (Bhaskar 1978). Too often, the reproducibility of the experiment is conflated with a presumed objectivity on the part of the scientist. These two things are separate and not reducible to one another.

It is this element of critical realism which is likely to cause most discomfort to the vast majority of academic scientists who deeply value the objectivity of science. Once again, scientific knowledge is objective, but scientists may not be. Whilst this shift in perspective may be a little uncomfortable to begin with, it allows scientists to explore the practice of science as a deeply creative process. This process must be connected to the real, through the empirical observation of actual events or through the precipitation of actual events brought about by the conditions of closure to create particular empirical outcomes. Thus, as scientists, we must continue to strive to describe what we have done in ways that others can reliably reproduce the work. However, exploration of new intellectual spaces is deeply personal and deeply creative.

As a brief aside, it is worth recalling that the use of the passive voice is prevalent in publications in the natural sciences. Cooray (1967) claims that the passive 'helps the writer to maintain an air of scientific impersonality.' Banks' (2017) study on the use of the passive voice in scientific writing from 1985 to 2015 indicates that the use of the passive voice is declining. Banks makes this note in the paper:

> Active voice with a first person plural subject tends to be used when the authors wish to underline a personal contribution, while passive is used for established or standard procedures. Where a contrast is made, authors tend to use the active voice for their own work and the passive for the work of others. And authors use the passive for speculating on their own future work.
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> (Banks 2017: 12)

This distinction between the use of the passive voice when describing an established procedure and using the active voice when describing new actions taken by the researcher is directly in line with raising the visibility of the scientist as an active agent.

Emergence and closure

Having established, then, that the real domain is open and that scientific research is the process of intentionally closing a system in order to observe a particular empirically observable event, it follows that not all systems may be perfectly closable. The degree of closure possible in the system is one of the variables in research of all kinds. It is related to the degree of separation between the human person and the aspect of nature under investigation. There are a few notable exceptions to the possibility of closure of the system in natural science. The first is Astronomy. When objects in the cosmos or indeed the entire cosmos are the focal point, any attempt to close the system is not feasible. But the difference in scale between any human action and the mechanisms being empirically observed mean that this is not likely to be a problem. The second exception is more complex. At the quantum level, we have evidence that the presence of the observer alters the outcome. However, in the middle ground where most scientific research is situated, it is possible to close the systems under observation sufficiently. Where there is a question of potential attainable degree of closure, 'control experiments' are used.

Critical realism is an emergentist philosophy. This means that it allows for complexity to give rise to new mechanisms; for example, the behaviour of cells may be explained on the basis of some molecular interactions but is not reducible to those molecular interactions. That is to say, if one had a full understanding of molecular interactions, the behaviour of cells would not be entirely predictable from that data set. In other words, the behaviour of cells is an emergent property that is dependent upon molecular interactions but is not entirely reducible to molecular interactions. Thus, Biology is related to and built upon Chemistry but is a field in its own right and cannot be entirely reduced to Chemistry. Thus there are real mechanisms that exist at the level of cellular interaction which are not reducible to the level of molecular interaction. This is 'emergence'.

This concept of emergence then provides a bridge into the social world. We have just seen that cellular interactions cannot be reduced to molecular interactions, although they are dependent on molecular interactions. Likewise, the actions of an individual human being cannot be reduced to physical responses of the organism. More importantly, for education research, and indeed social science research, society has real mechanisms that cannot be reduced to the individual and that the social world is not entirely reducible to the physical world. Thus, in critical realism social structures are considered ontologically real. They are not unchanging in the same way as physical structures are, but they do have a reality that is irreducible to the individual. Examples of this include language, nation states or the banking system. These things exist as a product of human culture, and they shape the person born into that culture in particular ways. As an example, Boas, a nineteenth-century anthropologist, pointed out the phenomenon of 'sound blindness,' where researchers who had grown up speaking a European language were simply unable to hear differences in sounds made in some Pacific Island languages (Boas 1889). These languages use differences in tone to alter the meaning of words; to people who speak European languages, these differences are not noticed.

Here the distinction between social science and natural science comes into view. There are two significant differences. Firstly, in social science, closure of the system is substantially more difficult to achieve. The person of the social scientist is interrogating the behaviour of other humans who are consciously aware of human interaction and thus the social mechanism under investigation may be influenced by the fact of the study. In education research in particular where the researcher may also be the teacher, it is clear that the system is not closed. Secondly, the mechanism(s) under investigation may arise from cultural context. The implication of this is that one is unlikely to achieve the degree of reproducibility in education research that one can in science research. All one can do is to describe the social world sufficiently so that the mechanisms in action that are particular to the context may be less obscure.

Natural science and social science

The 'real'

In knowledge creation, there are three domains in relationship with one another – the real domain under investigation, the conceptual domain within which limits the stratum of the real which is observed and the community of researchers who contribute intellectually to the defined conceptual domain. These three domains exist in both social science and natural science. But, the degree to which the real domain can be closed varies, and the degree to which the human person is visible as an agent in knowledge creation varies. Nonetheless, the underpinning position is one of realism – that there is a 'real' domain that exists independently of the individual human person and that can be investigated.

One goal in natural science is to develop concepts that describe a phenomenon in the physical world. A second goal is to use those concepts to develop new technologies. In an analogous fashion one goal of social science is to develop concepts that describe a phenomenon in the social world. A second goal is to examine the ways in which social power operates in society. The exploration of the nature and dynamic of social power is thus a major focus of sociological research.

For a person coming from a background of natural science, there are two important conceptual elements which may not be immediately obvious. Firstly, that the social world does indeed have real mechanisms which give rise to events which are empirically observable. However, it is substantially more difficult to isolate and attribute cause unambiguously to a mechanism in the social world. Secondly, there are always social power dynamics in play. Thus, research into the description of those power dynamics is a legitimate form of knowledge-building activity. It is entirely possible to attempt to hold both goals in view at the same time, but it is more common for one goal to be favoured.

Knower-blindness

The impact of operational naïve realism on the practice of science is what Maton calls 'knower-blindness' (Maton 2014: 14). This is in contrast to the 'knowledge-blindness' which was prevalent in sociology of education literature in the 2000s (Maton 2014). The potential reality of knowledge was obscured. Thus, what was taught was de-emphasized in favour of developing the 'voice' of the student (Moore and Muller 1999). This can be understood as conflation of ontology (what is real) and epistemology (what is known) thereby reducing the real to what is known. All becomes epistemology, and there is nothing beyond the constructed concept. This position can be called ontological constructivism. This shift was prevalent in the social sciences and dominated the sociology of education in the 1980s and 1990s. This certainly influenced some science education too (Scerri 2003), but the impact was not felt significantly in tertiary science education. This may be because tertiary science educators have been largely ignorant of the science education literature until the push of scholarship of teaching and learning discourse became mainstream in higher education in the last decade.

In contrast, because scientists involved in tertiary education are also involved in scientific research, the position they tend to hold is naïve realism rather than ontological constructivism. As described above, natural scientists can tend to be blind to the influence of the social world on scientific research. Again there is a conflation between ontology and epistemology, but here the error is in the opposite direction. Epistemology is promoted to ontology: the concept is taken to be that which it was constructed to describe. Hence where social science erred towards knowledge-blindness, natural science erred towards knower-blindness.

The consequence of this is a lack of recognition of the significance of society on the propagation of science. A caricature of this was present in the response of some scientists to call for decolonization in the #FeesMustFall protests in South Africa. The position was clearly that science is inherently socially neutral because it is objective; therefore, there is no possibility of a decolonized science curriculum (Adendorff and Blackie 2020). This position is one of naïve realism. From this position, when one observes a social dynamic at play in education, the desire is to remove the social dynamic to retain the holy grail of objectivity in science education. This is reinforced by the use of the passive voice in the scientific literature mentioned above. However, critical realism would suggest that this move is a fool's errand.

As scientists begin engaging in education research, a major mental shift needs to happen. We must bring into view the reality of the social structure. Here, as previously mentioned, it is important to recognize that social structure also has an ontological reality that is irreducible to the action of the individual. One of the most influential authors on this point is Margaret Archer (2000), who, building from a critical realist starting point, argues for the importance of recognizing the impact of both structure (the level of society) and agency (the level of the individual) in effecting any kind of impetus to transformation.

Role of the concept

I have already indicated the problem of naïve realism where the distance between the conceptual world and the physical world is collapsed. In science, the conceptual world is a constructed world that has correspondence to the physical world. In the idealized notion of how science progresses, the concept shifts from a proposal to something that is generally accepted by the field. This process follows several steps. Initially, a scientist publishes a paper describing the observation of a particular empirical phenomenon. This phenomenon is then investigated by others and sooner or later a mechanism to explain the phenomenon is proposed. The limits of the mechanism are then explored, and the mechanism is refined. These refinements are in turn published. After another period of time, a single refined mechanism becomes favoured and is taken to be accepted knowledge. From this point on, two independent processes occur. Firstly, the refined mechanism subtly shifts from being an explanation for an empirical observation to being 'how the world is.' That is the distinction between the conceived mechanism and the real physical mechanism collapses. This is the slippage into naïve realism. Secondly, the refined mechanism becomes the conceptual foundation which shapes the way the scientist thinks. In this second sense, the concept does become real. Its existence has an influence on scientists working in that field. Concepts frame the way in which we approach our scientific enterprise. Having indicated that the scientists may not be the source of objectivity in science, it is important to acknowledge here that the acceptance of a new concept by the community of scientists is surely somewhat influenced by politics and personal power.

Teaching science

Most of the fundamental sciences are well established in that there is a broad, robust conceptual foundation. For many of the established sciences, there has been little change to this foundation in the last several decades. There are some exceptions – for example, developments in Molecular Biology are ongoing and continue to shape aspects of Biology. Nonetheless, there is usually general consensus on the conceptual foundation which forms the basis of many undergraduate science programmes. So science programmes across the world tend to have a common core.

At this point, it is helpful to introduce the idea of the 'epistemic–pedagogic device' (Maton 2014). This idea is built upon the foundation of Bernstein's 'pedagogic device' (2000). There are three interrelated fields of practice in education:

- The *field of production*, where 'new' knowledge is created (in science, this is often the research laboratory).
- The *field of recontextualization*: where knowledge from the field of production is selected, arranged and evaluated as curriculum and textbooks for use in teaching and learning. (In science, this is usually done by the authors of textbooks, although in some countries, professional bodies may play an active role in defining curricula.)
- The *field of reproduction*, where students are taught and learn a subject area (in science, this is the lecture theatre and the teaching laboratory).

If we are working from a position of naïve realism rather than one of critical realism, we may not notice that there is an active process of reproduction. In the case of most university courses in the sciences, where a textbook forms the foundation of a course, few of us will have any engagement in the field of recontextualization other than to make a choice of textbook. In hierarchical knowledge structures where concepts are strongly interrelated and build from a common foundation such as are present in many of the fundamental sciences, there may be relatively little choice around what is included and what is excluded from the curriculum. In addition, because we are interested in developing conceptual thinking rather than fostering a way of viewing the world, the choice of what is included and what is excluded is far less obviously subject to social power and political capital. However, the conversations around decolonization in the different faculties of South African universities show that this is indeed a little more complex than we might first imagine.

In science education though, it is useful to at least pause and notice that the field of production and the field of reproduction are separated from one another. The way in which we teach science can be remarkably different from the way in which we practice science. In some cases, the science that we teach can become so neatly packaged and internally referenced that it requires little experiential involvement from the student. In fact, in many cases, we inadvertently operate from a presumption that the student is a blank slate and we, as educators, are there to draw a good solid conceptual outline that the student can fill in. Alex Johnstone (2010), a powerhouse in chemistry education research, gave a scathing critique of Chemistry education in precisely these terms:

> We need to rethink a lot of what we teach. This does not imply that we have been teaching bad chemistry, but rather that we have been teaching inappropriate chemistry at the wrong time and in the wrong way. We have been presenting chemistry in a way contrary to what we now know and understand about learning.
>
> (Johnstone 2010: 23)

Thus, it may be that the way in which we teach science does not necessarily bear any relation to the way in which the student relates to the world. Our curriculum may be a beautiful conceptually coherent synthesis but if it fails to provide a bridge to the lifeworld of the student, the subject will remain disconnected and potentially inaccessible.

The important point here is that there is a significant shift in focal point between research and teaching. When we teach science, the conceptual domain is central but frequently fails to recognize that the construction of the conceptual domain is a fundamentally social activity. The process of passing knowledge on is infused with and embedded in society and culture even when we are teaching things that appear to be socially neutral like the structure of the atom. To fail to attend to the power and reality of the social is naïve at best and wilfully ignorant at worst.

There are many ways to improve our educative offering. In this book, we have focused on LCT, which is just one of the frameworks that can be used to achieve this end. Several dimensions of LCT are described in more detail in Chapter 1 of this volume, and various enactments of each dimension are illustrated in detail in Chapters 2–11.

Legitimation Code Theory

What is Legitimation Code Theory?

LCT is a realist theoretical framework which has its roots in the sociology of education. Karl Maton's (2014) *Knowledge and Knowers* is the foundational text of LCT and is the source of much of what is written in this section. LCT is built on several sources. One of these is the work of Basil Bernstein who had an interest in making explicit the ways in which language was used to create social boundaries. Bernstein's work coincided with the massification of higher education and was therefore concerned with revealing the 'codes' in order to give epistemic access to people who did not 'belong' (Bernstein 2000, 2003). LCT, developed by Maton, aims to make visible the 'rules of the game' of any social field of practice (Maton 2014). Education is one such field of practice, and Maton's explicit driver is that of social justice. If the rules of the game can be made explicit to all, anyone can learn how to play and be successful. In addition, in making the rules explicit, they can be critiqued and where necessary changed to create a better system.

We have found that LCT appeals strongly to many STEM-based academics who have an interest in STEM education because of the clear focus on knowledge. The various dimensions of LCT afford different ways in which teaching and learning can be explored. Each dimension is well bounded and well defined. Thus LCT can be used to illuminate particular facets of teaching and learning through careful choice of the dimension and development of an appropriate translation device. Producing robust publishable education research does require more than this, but engaging with LCT to improve teaching is a very powerful first step that can be carried out relatively easily, even for a newcomer to STEM education research.

LCT can be used to excellent effect in STEM environments to reveal the challenges of conceptual complexity required for mastery in the subject. Here Semantics and the epistemic plane have proved to be useful tools thus far. Semantics allows the exploration of the threshold to conceptual grasp by separating out complexity from abstraction (Maton 2014). Complexity is the degree to which knowledge is condensed into particular practices, terms or symbols. Abstraction is the power of the concept to explain multiple empirical observations, for example, the concept of an atom is used to account for a multiplicity of phenomena studied under the umbrella of Chemistry. The epistemic plane (Maton 2014) allows the separation between the methods deemed as legitimate and the objects of study. When one is trying to determine the structure of a molecule in Chemistry, the object of study is clearly defined, but there are many methods which may be applied to give the necessary information. Alternatively, if one is trying to master a particular analytical technique, the method is clearly defined but the object of the study could be any molecule. These two kinds of study both qualify as 'Chemistry' but vary in the degree to which method and object of study are constrained.

LCT can also be used to plan lessons and structure curricula. The concepts of semantic waves and autonomy tours are useful here. Thinking about moving strategically between simple/concrete meanings and complex/abstract meanings and back again (semantic waves) is important in facilitating cumulative learning (Maton 2014). Considering what elements of experience or other knowledges can be drawn in to facilitate learning of the subject you are focusing on (autonomy tours) is an important part of integrating knowledge (Maton and Howard 2018).

At another level, considering the purpose of the degree and the kind of formation one wants to achieve through a particular programme may be augmented by the use of Specialization (Maton 2014). Is the exclusive focus on epistemic acquisition, or is there an element of professional development also in play? Considering what is required and therefore what is desirable can have a significant impact on designing a more integrated, or at least a more intentional, curriculum.

LCT can be used for myriad analyses, as well as the shaping of teaching practice. Nonetheless, it is useful to bear in mind the purpose of its creation – to make visible the 'rules of the game' for what makes a knowledge claim legitimate – who can make the claim and how the claim needs to be structured (Maton 2014). As such, it is clearly not just about knowledge but also about knowers. Ultimately, the purpose of most educative endeavours is to induct a novice into the field such that they have the capacity to become an expert. It is important to note that LCT is designed to be used in a fractal manner – that is, it can be used at any level, but we must be realistic about the limits of the spectrum accessible by the students. For example, if we are analyzing semantic density in an introductory course, we need to think about the capacity achievable by the top student end of the course, not the level that we have as academics.

Translation device

The feature of LCT which defines how the limits of the spectrum and the understanding of the spectrum within the specific context of your study is called a 'translation device' (Maton and Chen 2016). A translation device features at least three components. Firstly, the axis label representing the organizing principle or concept from the specific dimension (e.g. semantic density on the semantic plane), and the possible variations in strength, will depend on the level of refinement required by the specific study. Often, four levels of strength are described ++, +, – and – – although this should not be taken to be normative and a number of variations is permissible. Secondly, each of these levels of strength is given a specific description associated with, or determined by, the data set in hand. Thirdly, an example from the data should be included. This will make the interpretation of the study by the reader substantially more accessible and makes the study reproducible. Each axis (organizing principle) requires its own translation device.

The development of a translation device is usually an iterative process (Maton and Chen 2016). When one looks at the data, the possible variations begin to emerge. Suggested definitions or descriptions of the various levels of strength are then proposed and the data analyzed and coded accordingly. Inevitably, some data will not quite fit, and so the definitions will need to be modified or redefined. The analysis and coding then needs to be done again. There may be numerous iterations before the final translation device is settled upon.

The process of developing the translation device is an important learning curve. It is probably helpful if the researcher expects to be surprised in this process. In other words, the researcher should be open to learning from the data. It is here that we encounter the unexpected benefit of conducting research in a partially closed system. As we are likely to be researching elements of teaching our own discipline, we may discover new ways of thinking about what we are doing which may influence how we teach in the future. The stance here is not one of the disinterested expert but the researcher/practitioner/teacher who is willing to be shaped by the process of researching.

Conclusion

The purpose of this chapter has been to make visible the ways in which social science is related to natural science using critical realism as a framework within which to illustrate the distinctions. Many natural scientists will approach education research unconscious of the philosophical framework they are operating out of. The consequence is a desire for 'rigour' through approaches such as use of a control group or pre-test/post-test type methods. The recognition of the inherent partial closure of an education environment as opposed to the fully closed system possible in the natural sciences afforded by critical realism should make visible the fact that these approaches will not actually provide rigour. A well-considered description of the environment in which the study has been done and the intention of the researcher will be more useful than any attempt to artificially remove the particularity of the context.

It is likely that any scientist embarking on the journey of engaging seriously with education research literature will find this chapter quite dense itself. It is probably worth keeping it 'on file' and returning to it periodically over the first few years of the exploration. Learning how to navigate a new intellectual space is itself an iterative process, and the conceptual map provided herein will make much more sense against the scaffold that will begin to be constructed in one's own mind.

Perhaps the most important point raised herein is the recognition that as scientists we operate out of various presumptions. Calling these into question or indeed simply making them visible can illuminate our understanding of ourselves as scientists and can potentially impact how we teach science and make the task of engaging with education research a little easier. This process of illumination is at the heart of LCT. LCT seeks to make visible the implicit 'rules of the game' which are required to gain access to, and to produce, knowledge which is seen to have value (legitimated) within a particular field.

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