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# Indigenous knowledge systems and science education

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**Significance:**

The inclusion of indigenous knowledge into the curricula of natural science courses remains contentious. In this paper I use critical realism to show the relationship between these two forms of knowledge. An engagement with both knowledge structures could afford better pedagogy and assessment. In addition, the engagement with indigenous knowledge allows for the development of 'knower awareness' in the practice of science. Meaningful engagement with indigenous knowledge could therefore enhance science education, whilst making visible the socio-cultural relevance to students.

## Introduction

For nearly 20 years South Africa has had a formal indigenous knowledge policy.[1,2] Prior to the call for decolonisation of higher education institutions that accompanied the #MustFall protests of 2015/2016, natural science curricula at all levels remained almost impervious to indigenous knowledge systems (IKS). The decolonisation project has broad scope. One aspect of decolonisation is the interrogation of the curriculum content. It is at this level of curriculum content that the inclusion of indigenous knowledge systems intersects with the decolonisation project. The focus of this paper is limited to the incorporation of IKS into the natural sciences.

Most academics in the natural sciences presumed the call of decolonisation to be irrelevant to their disciplines until the #ScienceMustFall video went viral.[3] This video was a short clip from a debate which took place at the University of Cape Town during the #MustFall protests. In this video a student called for the replacement of Newton's Laws by indigenous knowledge. In the wake of that incident, natural scientists took heed and entered the decolonisation conversation. The knee-jerk responses by academic scientists fell into two broad camps. The first was to argue that science was objective and therefore decolonisation was not an issue. The second was a scramble to include South African examples into existing courses.[4] Both responses are inadequate, but the inadequacy is only made visible if we understand knowledge in the natural sciences.

I begin then with an exploration of knowledge and curricula, drawing on the work of Basil Bernstein. Bernstein's work on pedagogy and curricula has been used extensively in academic development work across South African universities.[5] In this paper, I argue that the link between IKS and science can and should be explored across all three fields identified in Bernstein's pedagogic device[6]: the field of production (where knowledge is created, e.g. the research environment), the field of recontextualisation (where the knowledge is packaged for communication, e.g. the development of the curriculum), the field of reproduction (where new knowers are exposed to the packaged knowledge, e.g. the lecture theatre). Work is being done across all of these fields, as is illustrated herein. However, the major focus of this paper is the field of reproduction. In the field of reproduction, I argue that it is necessary to be very clear about the relationship between IKS and Western science in order to communicate well.

## Approaches

In the intervening period, there have been multiple attempts to respond to the call for decolonisation by recognising South African knowledge in different ways. Some efforts are focused on widening what Bernstein terms the 'field of production'.[6] The field of production is the space in which knowledge is produced. The call for decolonisation is understood in a variety of ways, but all include a decentring of Western knowledge. But to de-centre Western knowledge requires the introduction of other knowledges. To achieve this end, some researchers are looking at indigenous knowledge practices and bringing these into public view through the vehicle of peer review publication. Examples of this include Manyevere et al.[7] who focused their attention on soil classification amongst Xhosa-speaking people in the Eastern Cape.

A second approach is to facilitate communication and knowledge transfer between academic scientists and local communities. This approach falls under transdisciplinary research approaches. "Transdisciplinary research seeks to integrate diverse knowledge from academic and non-academic actors to co-produce knowledge or solution options while reconciling values and preferences, and creating ownership for problems as well as solutions."[8] For example, Cockburn et al.[9] focused their attention on isiZulu names for insects found in KwaZulu-Natal in order to facilitate communication between entomologists and the local community. In Bernsteinian[6] terms, such efforts would be located in the 'field of recontextualisation' where the knowledge is packaged in ways which can be digested by people in different contexts.

A third approach is to incorporate indigenous knowledge directly into the curriculum. This sits in Bernstein's 'field of reproduction'.[6] There are more examples of these interventions in primary and secondary levels. For example, Metaus and Ngcoza[10] report on the incorporation of clay pot making by the Ovawambo people into a secondary school science curriculum in Namibia.

## What is the imperative?

The intention of the inclusion of IKS into science curricula is to valourise these traditional ways of knowing and thereby foreground the wisdom held in the indigenous peoples of South Africa.[11] Onwu and Mufundira[12] point to the "increase of socio-cultural relevance of science education" (p.230). Naidoo and Vithal, drawing on other studies, note that the inclusion of IKS into the curriculum can provide "motivation and self-esteem; cultural responsiveness and relevance; increased peer interaction, and positive learning experiences" (p.254).[11] There certainly is a need to ensure that the classic image of the scientist as a white, heterosexual, cisgendered male no longer prevails. There is also a need to disrupt the notion that science is a body of work produced by dead Europeans.[13] It is important that the 'field of production' of science is not falsely constrained to the research product of our higher education institutions. To this end, transdisciplinary research is an important innovation.

However, the inclusion of IKS into a science curriculum must be done with some care. One needs to recognise that the knowledge structures of IKS and Western science are not necessarily the same. Incorporating ethnobotany such as a module on wild edible plants in a botany course[14] can be used to show a different kind of classification in a module on plant taxonomy. Nonetheless, it is important to make visible to students the power of the classification system. To fail to point to the distinctions and relative power of different classification systems is a missed opportunity of teaching the way in which botanical knowledge is built. In a similar fashion, the brewing of traditional beer, *umqombothi*, is a chemical process, but the molecular understanding is not a part of the indigenous knowledge and this needs to be actively connected to chemistry if it is to be incorporated into a science curriculum.[15]

In order to ensure that IKS is appropriately incorporated into a science curriculum, one must consider the different kinds of knowledge. Carefully thinking this through allows for two important points: (1) We see that IKS and Western science are interrelated but are not the same thing. Careful observation and clear communication are essential to both. (2) We see that Western science in its quest for objectivity and reproducibility has failed to give sufficient attention to the particularity of the person who first develops an experiment to investigate a particular phenomenon.

## Critical realism offers a useful perspective

Critical realism offers a way to explore the relationship between Western science and traditional knowledge systems. Blackie[16], drawing on Bhaskar[17], argues that the practice of science is the intersection of three domains, illustrating this with the field of chemistry (Figure 1). The first domain is the physical world at the level of the molecular. The second is the 'canon of chemistry' – the knowledge field, that we know as the subject of chemistry, provides conceptual understanding to explain the real mechanisms and entities which give rise to changes at a molecular level. The third is the community of chemists. Because the science offers a conceptual explanation of real mechanisms which exist in the physical world, the fact that the concepts are socially constructed is frequently overlooked. In the physical sciences, the interrogation of the system to establish the causal mechanism takes place by closing the system. In chemistry, this closure is achieved through the use of specialist glassware. The scientist is not the passive observer of the system, rather they are an active agent in the design of the experiment, such that a single mechanism or sequence of mechanisms is isolated.[16]

Blackie[16] argues that there are two distinct ways in which science advances illustrated by the practice of chemistry. The first is 'chemistry as science' – where the theory is under scrutiny. The physical world is taken to be fixed and the conceptual world (the canon of chemistry) is under scrutiny. The second is 'chemistry as technology' – where the theory is taken as fixed and used to manipulate the physical world in new ways, e.g. known reactions are used to create new kinds of molecules. The focus in this paper is on 'chemistry as science'. 'Chemistry as science' is further subdivided into two levels. Level 1 is that of careful, accurate observation. A particular reaction or system is repeated over and over again and slowly refined. This level of careful description

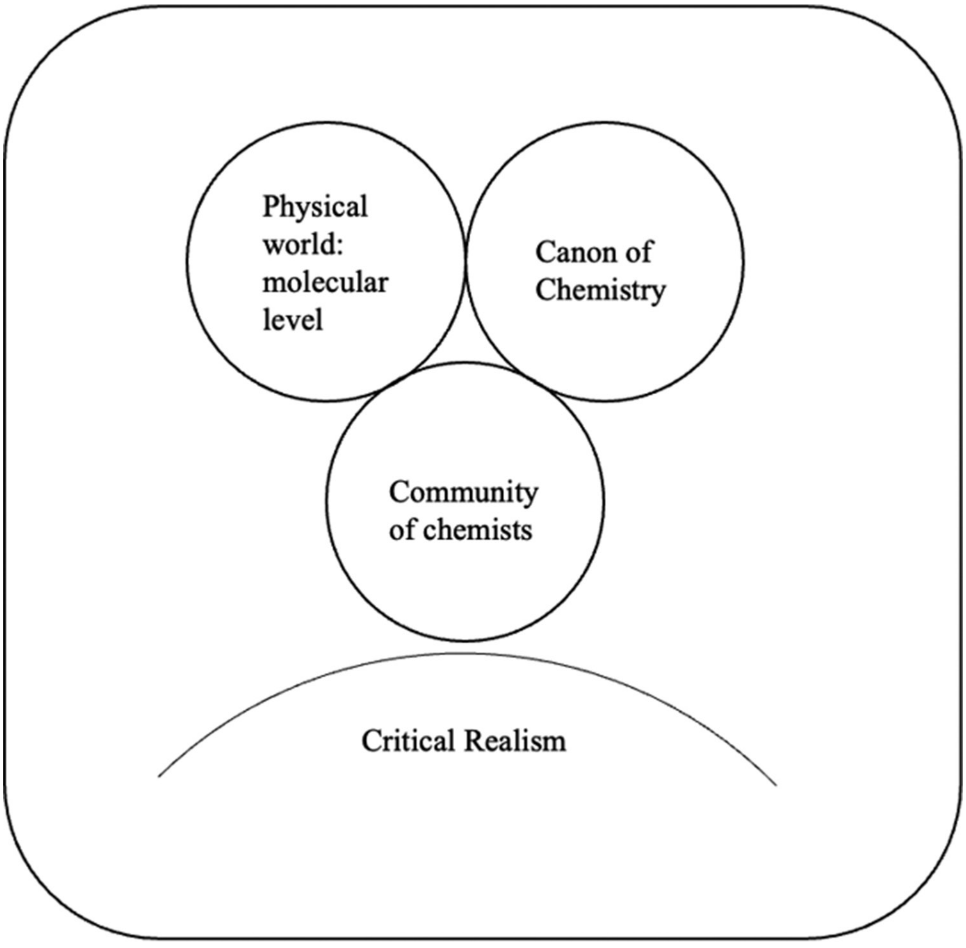


**Figure 1:** The practice of chemistry is the interaction between the three domains of the physical world: the molecular level, the canon of chemistry and community of chemists.

and observation is common to both Western science and IKS. Once the reaction can be reliably reproduced, the person can communicate the procedure to a second person. Because the underlying causal mechanism is real and is 'intransitive'[17], a second person following exactly the same procedure can reproduce the same result. In Western science, the established process of communication is through peer-reviewed journal articles. In indigenous knowledge systems, oral traditions are more common, and the knowledge is often passed on to specific individuals. At Level 1, there is no meaningful distinction to be made between Western science and IKS. Western science may incorporate the use of more accurate instruments whereas indigenous knowledge may use more sensory information, but these differences can be understood as the use of different 'tools' and so different kinds of description are used. Nonetheless, the fundamental process at work is essentially the same.

However, Level 2 of 'chemistry as science'[16] affords the power of Western science. At Level 2, an explanation for the observed empirical process is sought. Here it is not sufficient to know *how* to do a particular reaction, one must have a conceptual explanation for *why* the reaction is happening. Level 2 is built from combining and probing various Level 1 activities. For example, across the globe we have evidence of indigenous cultures having the technology to isolate the metal we know as iron from iron ore using a process of applying heat in a clay furnace. That is a Level 1 activity. It is only with the development of the science of chemistry that we can say that what is happening at a molecular level is the reduction of iron oxide using carbon from burning wood. The heat combined with restricted supplies of oxygen means that the oxygen is removed from the iron oxide to form carbon dioxide and iron. The development of the periodic table and the discovery of oxygen as a component of air was required before the explanation was possible. The discovery of oxygen was only possible once the substantially more accurate spring balance was invented and the art of glass blowing was refined. These two technologies were necessary to make possible the kinds of experiments needed to discover the nature of what previously had been described as 'phlogiston'. The accuracy of measurement of mass and isolation of gases could have been achieved through the creation of other technologies. Nonetheless, to our knowledge, there is no evidence of any indigenous culture creating equivalent technologies and so there is no indigenous molecular explanation.

It is on this foundation that I argue that indigenous knowledge and Western science are related but not interchangeable. In some sciences there may be a Level 2 equivalent in the indigenous knowledge system; it depends on the nature of the science and the dependence of the science on accurate measurement. Thus, when one is trying to combine IKS and Western science, one must be clear about what the Level 2 part of the science is and determine whether there is an IKS equivalent. Similarly, in some sciences, there may be large parts of the science that are still at Level 1. In such instances, IKS can be used alongside Western science. If the call for decolonisation is to decentre Western science, then one might argue that foregrounding the IKS when the science is primarily at Level 1 is the correct approach. However, when one is teaching chemistry, which is primarily at Level 2, to foreground IKS as equivalent to chemistry is inaccurate and misleading.

## Making the knower visible

As has been stated earlier, one of the arguments against considering decolonisation of tertiary science higher has been the notion that 'science is objective'.[3] However, this position conflates the objectivity of scientific knowledge with the objectivity of scientists. The fact that a particular chemical reaction can be reliably reproduced by a second person is not a magic quality of either person, nor is it the genius of the training. The reproducibility lies in the causal mechanism which exists independently of the particular person. Two different people can perform the same reaction and get the same result. This reproducibility can result in 'knower blindness' in science.[18] This knower blindness can also lead to the rejection of indigenous knowledge, because in order to have the increase in socio-cultural relevance and other positive impacts pointed to by various scholars[10-12], it is necessary to locate the indigenous knowledge in a particular people. For example, Mateus and Ngcoza[10] point to clay pot making by the Ovawambo people. This particularity of knowledge seems foreign to the universal claims made by science. The reproducibility afforded by the causal mechanism is conflated with an idea that scientists are interchangeable.

However, there is always a particular person bringing together a particular set of ideas to interrogate a particular phenomenon. Blackie and Adendorff[18] use the example of the attempts to determine the age of the earth by Kelvin and Joly. Each scientist brought their own skill set and understanding to bear on the problem. Kelvin turned to thermodynamics and Joly to the determination of the concentration of salts in aqueous solution. Science is in fact a profoundly creative endeavour.[19] Each scientist is shaped by their training, the language they speak, the environment in which they grew up and the sum of their life experience. All this influences the field of study and the particular focus of their attention. This is why Blackie and Adendorff[18] call for the importance of 'knower awareness' in the practice of science. Here, science can learn from IKS. The development of knowledge always emerges with a particular person in a particular place at a particular time. This allows for a major corrective of the Western tradition. We are not 'brains on sticks' – we are embodied beings and the fact of our embodiment matters.[19]

## Conclusion

There is a huge opportunity to develop resources which adequately honour indigenous ways of knowing and being. Nonetheless, bringing indigenous knowledge into a science course needs careful thought. The person teaching must pay careful attention to the knowledge structure of their field and of the particular section of work being taught and the knowledge structure of the indigenous knowledge they intend to incorporate. The indigenous knowledge must be connected at the appropriate level. Because of this requirement, the pedagogy of science could well be improved by engagement with IKS in two ways. Firstly, the need to focus on the knowledge structures could facilitate more meaningful assessment.[20] Understanding the knowledge structure affords the possibility of making knowledge building more visible to the students. Secondly, the significance of including local knowledge in terms of student engagement is important. This will help to facilitate the erosion of the image of the quintessential scientist as a white man.

It is also profoundly useful that an unexpected asset can be brought to science in the form of developing knower awareness. Knower awareness is an essential first step to the recognition that scientific knowledge can be used to different ends. Not all of these ends will be ethical and not all exploration of scientific questions is appropriate. Bringing to light the motivations of the person of the scientist is important. I believe that our practice of science can be enriched by intentional and careful incorporation of IKS into the knowledge project at all levels. This does not mean that IKS should be incorporated into every course.

## Competing interests

I have no competing interests to declare.

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