INDIGENOUS KNOWLEDGE SYSTEMS: ITS AFFORDANCES AND RESTRAINTS IN SCHOOL SCIENCE

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ABSTRACT – The advocates for the infusion of indigenous knowledge in the school science curriculum often make a compelling argument that the natural sciences and indigenous knowledge share many tenets, and therefore such epistemological border-crossing could be facilitated with relative ease. Several scholars have shown how indigenous knowledge could be taught in the science classroom, utilising the processes of science. Joint tenets of science and indigenous knowledge include its empirical, inferential and tentative nature. However, the Achilles heel in this argument is how to deal with the metaphysical nature of indigenous knowledge in the science classroom. The ontological nature of science builds on the empirical- the universe is orderly and predictable. In contrast, indigenous knowledge has a dual ontological nature: it is both empirical and metaphysical. Most scholars would argue that the science teacher should only focus on the empirical component of indigenous knowledge, and ignore metaphysics, which is not aligned with the nature of the natural sciences. However, in doing so, indigenous knowledge is ransacked of its holistic nature. In this paper the author investigates examples of metaphysics in ethnobotany, and suggests that there often are plausible explanations for what, at first glance, might seem to be 'pseudo-science' or metaphysics. Furthermore, when learners engage with the more metaphysical aspects of indigenous knowledge, they are provided the opportunity to measure such practices against the accepted tenets of the natural sciences, and differentiate between science and pseudoscience. The paper also analyses contemporary research trends and career opportunities related to science with an indigenous knowledge imprint, and argues that the exclusion of indigenous knowledge in the school curriculum, based on its metaphysical dimension, would disadvantage learners. The inclusion of indigenous knowledge in the natural sciences curriculum will alert learners to both career and entrepreneurial opportunities that they may pursue in future.

Keywords: Indigenous knowledge, science education, metaphysical nature of indigenous knowledge, contextualising science, pseudo-science, career and entrepreneurial guidance.

INTRODUCTION

Authors such as De Beer (2016), De Beer and Petersen (2017) and Petersen, Golightly and Dudu (2019) suggest that indigenous knowledge could be included in the science classroom in a scientifically rigorous way, honouring the tenets of the natural sciences, such as its empirical, tentative and inferential nature. An example is where learners engage in an adapted Kirby-Bauer technique (De Beer & Whitlock, 2009) in the school laboratory, whereby they test the anti-microbial activity of medicinal (muthi) plants. In such an activity the processes of science are used to explore the rigour of indigenous knowledge. However, indigenous knowledge is holistic, and also includes metaphysical aspects that are difficult to understand. Ongunniyi (2007:965) describes indigenous knowledge as 'a conglomeration of knowledge systems' that include science, religion, psychology and other fields. Based on these metaphysical aspects, many science educators advocate for the exclusion of indigenous knowledge in the school natural sciences curricula. Bringing the metaphysical dimension of indigenous knowledge into the science classroom, might easily promote pseudoscience. However, excluding indigenous knowledge might leave learners ignorant of a myriad of career and entrepreneurial opportunities that exist. This paper answers the question, 'How could reference to metaphysical aspects of indigenous knowledge in the science classroom assists learners in developing more nuanced understandings of the nature of science?'

ON SCIENCE AND PSEUDOSCIENCE

Central to this paper, is the question whether indigenous knowledge should be seen as science or pseudoscience. Coker (2001:1) lists a number of characteristics of pseudoscience, namely that it displays an indifference to facts, that pseudoscience research is invariably sloppy, that it ignores criteria of valid evidence, it relies heavily on subjective validation, it avoids putting its claims to meaningful testing, and that 'pseudoscientists often appeal to an ancient habit of magical thinking' (p. 4). Later on in this paper a case study is provided, and these features listed by Coker could be a good litmus test to distinguish between science and pseudoscience.

METHODOLOGY

With the national attention (e.g. fuelled by NRF initiatives) given to indigenous knowledge systems currently, there are many opportunities to firstly contextualise 'western science' to diverse South African learners in the science classroom, and also to provide them an overview of emerging career opportunities in the field of indigenous science. For this paper the author firstly analysed all the papers presented at the most recent Indigenous Plant Use Forum (IPUF) conference (7 – 10 July 2019, in Tshipise, Limpopo Province), to get a sense of the ethnobotanical-, ethnopharmaceutical and agricultural research that are being done, and the opportunities provided for a future generation of young scientists and entrepreneurs. IPUF is a unique conference which brings together researchers and practitioners, and the papers reflect cutting-edge research and latest trends. The author has analysed the 65 posters and research papers, using as criteria (a) science innovation that could supplement the CAPS curriculum themes; (b) indigenous knowledge that could better contextualise school science; (c) papers that could provide learners with more insight into the tenets of science; (d) entrepreneurial opportunities that could be explored in the classroom; and (e) possible career opportunities. Through this analysis the author shows why it is important for science educators to take note of the growing ethnobotanical and ethnopharmaceutical fields, and why this should also be incorporated in school science education. While listening to the papers, the author realised that the current school Life Sciences curriculum does not adequately prepare learners for the type of career opportunities that are emerging in the complex 21st century, and that, sadly, the majority of teachers do not have the knowledge to bring ethnobotany and ethnopharmaceutical research into their teaching. One of the reasons why such indigenous knowledge is often avoided, is the fear that pseudoscience might be promoted (Mothwa, 2011). If this is the case, it is important that classroom discussions on what constitutes pseudoscience should be conducted. The second part of the paper focuses on a few anecdotes on "magic" plants, and how there are often good scientific explanations for practices which seems to be, at first site, pseudoscience.

NASCENT SCIENCE FIELDS: ETHNOBOTANY AND ETHNOZOOLOGY

Sixty-five papers and posters were presented at the 2019 IPUF conference, and these were analysed to assess its relevance to the school Life Sciences, Physical Sciences and Natural Sciences curricula, and what affordances it holds for the classroom. We need to ask ourselves the question whether indigenous knowledge in the school classroom is portrayed as cutting-edge science, or whether lip-service is paid to indigenous knowledge through referring to an example of two. The analysis is shown in Table 1.

Table 1: An analysis of themes emerging from the IPUF 22nd Annual Conference

Number of papers/ posters	Central theme of paper/poster	Relevance to the natural science classroom
8	Extraction methodologies, e.g. chromatography, the role of solvents, in ethnopharmacology studies. (Techniques for analysing active ingredients in plants have developed rapidly).	Metabolites are extracted by using sophisticated techniques, and these are relevant in several Life-, Physical and Natural Sciences themes. This is also an increasingly growing industry, with many career opportunities.
5	Testing the antimicrobial activity of plants (these include a wide variety of specialisations, e.g. the antimalarial activities of *Artemisia annua* (Anyomih, Kinfe & Van Wyk, 2019); work on *Terminalia ferdinandiana* as a treatment for HIV/AIDS (Cock & Matthews, 2019); cancer studies; STD's.	Links well with the microbiology section of the natural- and life sciences curricula. It also addresses sections in the curriculum on diseases such as malaria and AIDS. This is becoming an important industry in terms of job creation. These insights might also show learners how science provides

		solutions to the biggest problems facing humankind (such as the AIDS pandemic).
3	Safety and toxicity of plant extracts (this also includes issues of ethics, e.g. using animals such as Zebrafish (*Danio rerio*) in experimentation (Lepule, Mhlongo, Chipiti, Sowesa & Viljoen, 2019).	*Danio rerio* show a high genetic homology (70%) to humans, and can be used for experiments instead of rats or frogs. This addresses issues of ethics in the lab. It also provides many learners, who might consult traditional healers, with some of the problems with alternative medicines, such as dose and toxicity.
12	Food security and food cultivation (including environmental concerns, e.g. water use)	There is an international market for South African plant products. This growing field is creating many specialised career- and entrepreneurial opportunities.
3	Beverages (e.g. wine and beer) made from plants	South Africa has a high unemployment rate, and entrepreneurship should be encouraged amongst students. However, this theme also speaks to the curriculum content on anaerobic fermentation.
3	Plants and cosmetics	A theme that can be integrated in both life sciences and chemistry. Saponification can be easily explored in the science classroom, e.g. while making soap.
14	Ethnobotany of medicinal plants. Many South Africans rely on traditional healers for health care, and a large number of research projects are focusing on the efficacy of these medicines.	Not only can this be infused when dealing with the different body systems in life sciences, but learners can also develop more nuanced understandings of the nature of science- e.g. how is this research conducted?
2	Conservation of indigenous plants	Environmental conservation is a central theme in the curriculum.
4	Essential oils in plants	Essential oils are not just of medicinal importance, but also in the cosmetic industry. Many career- and entrepreneurial opportunities exist.
8	General ethnobotany and plant taxonomy	This relates well to the section on classification in the curriculum.
2	Ethnobotany and metaphysical aspects ("magic plants")	This provides learners the opportunity to engage with the nature of science. What constitutes "pseudoscience"?
1	Ethno-veterinary uses, such as medicinal plants used in curing cattle	Not only would this relate to many learners in rural areas (thus better contextualising the curriculum), but it also shows how our local flora hold promise as ethnoveterinary medicines.
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Table 1 shows that indigenous knowledge research could potentially open up many entrepreneurial and career opportunities for learners, and that care should be taken to not simply exclude indigenous knowledge due to its (sometimes) metaphysical dimension. While attending these papers during the IPUF conference, the author realised that, despite the fact that he quite recently (in 2012) obtained a MSc in botany, he would not be able to provide learners in school with an updated view on ethnobotanical developments. He simply does not have sufficient knowledge of this almost exponentially growing science. This made the author realise what injustice we do to school learners, as a large percentage of teachers do not hold postgraduate or recent qualifications in the natural sciences, and are most likely unaware of these developments. The danger exists that, in our ignorance of indigenous knowledge research, it gets labelled as 'pseudoscience', without taking cognizance of the sound science that often underpins it.

It would therefore hold much affordances if teachers could infuse these insights into their teaching. However, one of the categories listed in Table 1, is that of "magic plants", and this warrants more attention.

"MAGIC PLANTS": TO DEAL, OR NOT TO DEAL, WITH METAPHYSICS IN THE SCIENCE CLASSROOM

De Beer and Van Wyk (2019) provide an interesting example that could be dealt with in the life sciences classroom, related to the use of "magic" plants. These authors refer to the very poisonous creeper 'impinda' (*Adenia gummifera*), a plant which is commonly sold at traditional muthi markets. A decoction of the stems is traditionally used to sprinkle around the house, to inhibit 'evil spirits' (Van Wyk, 2015; De Beer & Van Wyk, 2019). Van Wyk shows that, in modern western households, bleaches and antiseptic products (e.g. Jik) are used for the same purpose, namely to inhibit the growth of micro-organisms. For indigenous knowledge holders, who are often illiterate, and who do not have microscopes to see micro-organisms, 'evil spirits' is the terminology used to describe the germs that cause diseases. Such people have realised that 'impinda' is an effective antiseptic (De Beer & Van Wyk 2019). Through careful observation indigenous knowledge holders have realised that impinda is a plant with strong antimicrobial properties, which could be used in household hygiene. By discussing this in the science classroom, learners will realise that there is nothing wrong with the science itself, but that it is more a question of terminology. (For illiterate people who did not have knowledge of pathogens, 'evil spirits' was the cause of disease). This example provides a good vehicle for learners to engage with the tenets of science.

An interesting case study: agricultural practices, music and seed germination

Learners should be critical consumers of science research. An interesting example to use in the science classroom, to discuss science and pseudoscience, is the influence of music on seed germination. In Maranao culture in the Philippines, rituals form part of agricultural practices. Planting activities (mainly rice) are accompanied by music, chanting, and dances (World Intellectual Property Organization, 2006; Dimaporo & Fernandez, 2007). The latter authors claim that these ceremonies are not simply superstitious cultural practices, but that there is a body of scientific literature that indicates that music has the potential to lead to better seed germination. It has been shown that sound, as an external factor, has a big influence on the biological index of plants (Bochu et al., 1998; Zhao et al., 2000; Chowdhury et al., 2014). Several studies have reported enhanced seed germination in various seeds when exposed to music. Although the influence of sound waves on plant tissues is still not well understood, several research studies provide evidence that sound waves influence plant cell morphology, biochemistry, and gene expression. Possible reasons for better seed germination when exposed to music given in literature include, among others, an increase in the concentration of metabolites (Chowdhury & Gupta, 2015); changes in the elastic modulus and the viscosity coefficient of the plasmalemma (Wang et al., 2001); an increase in intercellular Ca^{2+} (part of the secondary messenger system) that can change the activity of membrane-bound enzymes (Wang et al., 2002; Teixeira da Silva & Dobránszki, 2014); and altering the secondary structure of cell wall proteins by changing amide I and amide II bonds (Chowdhury et al., 2014). It is important that students engage in the tentativeness of science as a tenet, by discussing this example. Many scientists do not agree with this claim that music could enhance seed germination, and critique is often that such studies were published in journals of questionable quality. The website Soundscapes (2015) traces this research back to the book, '*The secret life of plants*' that was published in 1973, and which is criticized as promoting pseudo-science. By engaging in this conundrum, students will learn more about the tenets of the nature of science. The hypothesis that music could enhance seed germination could be accepted or rejected, based on evidence (the tentative nature of science). Furthermore, students will be able to get to a better understanding of how scientific research is communicated (in peer reviewed journals). De Beer (2019) shows that students (in cooperative learning fashion) could plan and execute experiments to test the influence (if any) of music on seed germination. This is a challenging assignment, due to the number of independent variables (different types of instruments and how they sound), dependent variables (rate of seed germination), and controlled variables (light intensity, temperature, water, etc.). In such epistemological border-crossing between natural science and indigenous knowledge, learners will come to a better understanding of the tenets of both science and indigenous knowledge. Learners will have to measure such research against the tenets of science (it is empirical, inferential, objective, etc), and also against the characteristics of pseudoscience as listed by Coker (2001).

CONCLUSION

The author is of the opinion that the metaphysical dimension of indigenous knowledge should not be completely ignored in the science classroom. Although the predominant focus should be on the shared tenets between science and indigenous knowledge (e.g. its empirical and inferential nature), the metaphysical component is a dimension of indigenous knowledge that should be acknowledged. By engaging with such metaphysical aspects, learners could develop more nuanced understandings of the nature of science, and to distinguish between science and pseudoscience.

It is recommended that in-service training opportunities should be provided to natural- and life sciences teachers, in order for them to infuse these new developments in ethnobotany and ethnopharmacology in the classroom. South Africa could learn from the 'Target Inquiry at Miami University' (Mackenzie, 2001), an initiative that focussed on creating authentic laboratory learning experiences for science teachers. Such knowledge and skills would assist teachers to mainstream the affective domain, and alert a young generation of novice scientists of the career and entrepreneurial opportunities that science and indigenous knowledge hold.

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