

Teacher Learning through Tapping into Indigenous Knowledge Systems in the Science Classroom

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Abstract

This article reports on a qualitative study that involved re-thinking and re-doing teaching, by exploring the value of incorporating practices and knowledge embedded in indigenous knowledge systems. It begins by troubling the notion that all knowledge systems not rooted in the western mode of thinking are ‘naturally’ subaltern. The article focuses on pre-service science teachers who experience challenges when they engage with different epistemologies to inform their practice. Their responses to these challenges are explored through the following research question: How do pre-service teachers learn to teach culturally inclusive science? Drawing on the constructs of sociocultural theory and the Zone of Proximal Development, the way in which pre-service teachers learn was explored. A sample of 30 pre-service science teacher volunteers, who are part of a total population of 98 individuals that study a pedagogic content module at a tertiary institution in South Africa, participated in this study. The methodology describes how the pre-service teachers were trained, through module activities, to teach culturally inclusive science. The participants worked co-operatively in groups and generated lesson plans, as well as written reflections on their activities, which served as the data. The findings reveal that pre-service teachers can, through module activities, be enabled to refer to multiple sources of information, including custodians of indigenous knowledges, as legitimate, relevant and valuable holders of knowledge. Collaborative work among pre-service teachers can increase their confidence to draw on different knowledge systems, by transcending familiar pedagogical boundaries when they train to teach school science. Included among the recommendations is pre-service

teachers' call for modules taught at tertiary institutions to include IKS as a compulsory component. The article concludes by revealing how the incorporation of IK into mainstream knowledge production can contribute to epistemological decolonisation and the restoration of African identity.

Keywords: Pre-service science teachers, indigenous knowledge systems, Zone of Proximal Development, western school science, teacher training

Introduction

Historically, the knowledges of indigenous people have been devalued (Corsiglia & Snively 2001). This is attributed in no small part to socio-political ambitions of their colonisers. Colonial education was transmitted in a way that stifled the engagement with a gamut of different epistemologies. The imposition of the curriculum of colonisers, which was foreign to many autochtons, muted critical thinking in its quest to re-mould what were seen as 'uncivilized natives' so that this Other may bear some, but never complete, resemblance to the colonisers (Kanu 2008). One vehicle used by colonisers to subjugate indigenous knowledges in their attempt to eradicate the identity of indigenous people was the school curriculum. The postcolonial era has heralded critique of the curriculum as a means to 'cultural superiority, ideological indoctrination, power and control over others' (Kanu 2008:9), and this has resulted in a fundamental re-thinking of the curriculum. This has led to a move beyond the representation of western, eurocentric knowledge, by creating spaces for the re-emergence of indigenous knowledges in school curricula.

Globally, many teachers are expected to adapt to changes in curriculum policy. The South African educational context has witnessed multiple shifts in curriculum policy during the past two decades, due to political, social and economic influences that emerged at the dawn of its democratic era. The curriculum transitioned from the form dictated by Christian National Education, which promoted the values and knowledge of the dominant (mainly white) racial group, and which conceptualised this as 'official knowledge' (Kanu 2006:5), to the National Curriculum Statement (NCS), which aimed to confer cultural legitimacy on the knowledges and values of all South Africans.

The National Curriculum Statement was based on the notion of ‘science for all’, and in keeping with the transforming socio-political environment, adopted a more humanistic approach. This was enshrined in the school curriculum policy for Natural Sciences as Learning Outcome 3, which promotes the teaching of indigenous knowledge systems (IKS) in the science classroom (Naidoo 2010:23). A more recent policy document, the Curriculum and Assessment Policy Statement (CAPS) for Natural Sciences, aims at ensuring that ‘learners acquire and apply knowledge and skills in ways that are meaningful to their own lives. In this regard, the curriculum promotes the idea of grounding knowledge in local contexts’ (Department of Basic Education, DBE 2011:3). The CAPS document underscores the following principle: ‘Valuing indigenous knowledge systems, acknowledging the rich history and heritage of this country as important contributors to nurturing the values contained in the Constitution’ (DBE 2011:3). The principles and aims of the curriculum are formulated to be achieved through specific aims, which outline those cognitive competencies to be developed by learners. These policy changes signal a route towards curriculum reform, a way to reconceptualise the curriculum to make it more sensitive and responsive to the ‘multiplicity, difference and identity affirmation that conditions the postcolonial’ (Kanu 2006:7).

Many practicing South African teachers, however, are not in favour of the change in curriculum, because this new curriculum expects more of teachers (Hewson, Javu & Holtman 2009). Teachers indicate that there is minimal support in terms of the actual content and pedagogic content knowledge (PCK) of IKS integration in the science curriculum. Ogunniyi (2007) and Govender (2009) confirm this, by asserting that many science teachers do not implement curricula which include IKS, because they lack the relevant knowledge and skills. This brings to mind the following observation that curriculum reform is ‘not a neat, linear movement from one curriculum space to another. Rather, it is fraught with tensions, conflicts and contradictions that are indeed necessary for change to occur’ (Maistry 2011:119).

Responses of practicing teachers to a changing curriculum have been widely documented. However, there is a paucity of research about how pre-service teachers respond to changes in curriculum, especially in terms of incorporating IKS into the science curriculum. In South African schools, the Natural Sciences learning area emphasises conceptual development, which

should be linked to learners' contexts. This presupposes that pre-service teachers would develop a deep understanding of learners' contexts, including indigeneity, alongside mastering school science concepts, the latter which are grounded in a western worldview. This situation is a complex one. The Nature of Science (NOS), in which school science is embedded, is characterised by a parochial conceptualisation, compared to the holistic, plural, redemptive views of human experiences promulgated by IKS; and this presents a challenge to pre-service teachers (Ogunniyi 2007). We address here the challenge related to how pre-service teachers incorporate IKS into Natural Sciences lessons, given the different philosophical underpinnings of the nature of science and indigenous knowledges. We use the lens of an interpretive paradigm to approach the following research question: How do pre-service teachers learn to teach culturally inclusive science? In this article, culturally inclusive science is taken to refer to school science that engages with alternate knowledge rooted in indigenous knowledge systems. The data set informing this study includes pre-service teachers' lesson preparations, the resources that they choose to teach IKS in the Natural Sciences classroom, and their reflections on their practice.

South African School Science Education and IKS

IKS is conceptualised as a dynamic, complex human system comprising experiences of trial and error, practical wisdom, applied knowledge and historically acquired experiences, embedded and shared locally through collective structures and diverse learning modes. The marginalisation of IKS is acknowledged by Ogunniyi (2004) and Corsiglia *et al.* (2001), who emphasise that there is the perception that only the knowledge rooted in western systems of thought is regarded as valid. Ogunniyi (2004) argues that the practices which are embedded in the cultural values of African people have begun to wear away, because of the influence of western science in the education system of schools. Bishop (1990) states that the re-emergence of ethno-science has resulted in the revival of IKS in education. In one dictionary, ethno-science is defined as 'the study of the systems of knowledge and classification of material objects and concepts by primitive and non-Western peoples' (www.dictionary.com). Embedded within this definition is the notion that knowledge systems which are held by non-western people are

subaltern; it is this perception that creates difficulties when ethno-science is alluded to in the science curriculum. Ogunniyi (2004; 2007) points out that because the re-emergence of IKS is still in its elementary stage, the insight into and experience of IKS is limited, and this poses challenges for its inclusion in curricula. This challenge is compounded by linguistic barriers, because the same word can be interpreted differently by different cultural groups.

A critical analysis of the NCS by Botha (2010) has resulted in the authors' conclusion that western science dominates the NCS and that the worldviews of indigenous people of South Africa in education continue to be relegated to the margins. Botha (2010) calls for the South African education system to represent the demographics of the country, and to be more inclusive of and responsive to African traditions and culture. It is argued here that this can be achieved by adopting a more collaborative approach to science teaching and learning, where indigenous knowledge and western science are combined. The review of the literature indicates that while IKS and its philosophy have made inroads into critical pedagogy theory and that indigenous methodologists can 'speak to the oppressed, colonized persons living in postcolonial situations of injustice ...' (Denzin, Lincoln, & Smith 2008: x), IKS is still in its development stages, which require more sustained research into school and university curricula.

South African Universities and IKS

Amongst the principles and aims of the NCS is the requirement that school science should take cognisance of the learner's social context, in order to be meaningful (Department of Education 2002). This has implications for the type of training which teachers receive at higher education institutions. Currently, higher education institutions are considering the potential value of IKS and are re-designing courses/modules to recognise IKS. Naidoo (2010:14) alludes to the establishment of IKS faculties in certain South African universities; this signals a heightened awareness of the importance of focusing on IKS in tertiary education. Some universities have introduced a Bachelor of IKS degree, which confirms the endorsement of other ways of knowing by these institutions. The University of KwaZulu-Natal (UKZN) has the vision of being 'the Premier University of African Scholarship' (UKZN

vision and mission 2013). This university aspires to achieve this vision by promoting Indigenous African Knowledge Systems (IAKS) through the establishment of a dedicated office. The IAKS office at UKZN aims to, among other things, achieve the following: advance the development of teaching multidisciplinary undergraduate and postgraduate programmes, design an institutional policy for IKS development and protection, promote institutional awareness of IKS, plan research based workshops on IKS methodologies, and conduct institutional audits to generate a database of research projects and academics working in the field of IKS (Kaya 2012). At the University of KwaZulu-Natal's School of Education, pre-service teachers are given an 'indigenous voice', whereby culture and indigenous knowledge are included in the teaching of a science concept, astronomy (Govender 2009). According to Govender (2009), pre-service teachers are aware that indigenous practices are not simply ways of doing, but that they involve intellectual engagement, and this motivates these teachers to create ways to incorporate IKS in the science classroom. A theoretical understanding of how pre-service teachers learn to teach IKS is vital in order to advance African scholarship.

Theory

We engage with constructs from the sociocultural theory of learning and the concept of the Zone of Proximal Development (ZPD) as advanced by Vygotsky (Wersch 1985; Williams & Burden 1997; Ellis 2000; Shayer 2002; Lantolf 2002), in order to understand how pre-service teachers learn to teach IKS. Turuk (2008) states that sociocultural theory advances the notion that learners acquire knowledge by interacting with other role players (for example, teachers and their peers). This knowledge first develops in the 'interpsychological plane', after which this knowledge is assimilated and augmented with personal value, representing knowledge development at the 'intrapsychological plane' (Turuk 2008:245). According to sociocultural theory, the learner does not replicate the teacher's knowledge, but during appropriation, transforms and internalises knowledge. This marks the shift from social to personal knowledge.

Proponents of the sociocultural theory of learning argue for 'learning in interaction', as opposed to 'learning through interaction' (Turuk

2008:248). When they encounter a new task, learners interact with their peers or teachers (engage in social interaction), are then assisted by them, and eventually succeed in performing the task independently (Turuk 2008). Vygotsky (1978) extended the sociocultural theory of learning by arguing that consideration ought to be given to learners' potential ability to learn, beyond that which matches their actual level of development. This he referred to as the ZPD. A fundamental tenet of Vygotsky's ZPD is that developmental processes associated with learning are activated when learners interact with other people in a collaborative way. The ZPD is contingent, therefore, on the role of instruction (from the teacher), as well as the learners' biological development. Drawing on Vygotsky's ZPD, Turuk (2008) concludes that instruction which leads to meaningful learning should be more advanced and superior to the learner's actual intellectual development stage; such instruction will galvanize multiple functions, which are in the ZPD and are associated with learning.

This theory is relevant to this study because we explore how pre-service teachers learn to teach IKS in a subject called Natural Sciences, through mediation and scaffolding. We examine how they extend their familiar lesson plans, which involve the teaching of knowledge and skills in school science located in western ways of knowing, to teaching science that includes alternative knowledge systems.

Training to Teach Culturally Inclusive Science

The participants who were pre-service teachers in their third year of study engaged with a PCK module, which included integrating IKS into the teaching of science. These pre-service teachers were identified as a suitable group, because they were familiar with the school curriculum policy, and they had engaged in teaching at schools. Their experience of school-based teaching gave them unique insight into how teachers implement curriculum policy and how learners respond to the curriculum. In addition, the module template included constructivism as a learning theory, as well as IKS. The teaching of both topics was facilitated by creating the opportunity for pre-service teachers to think deeply about how learners can actively construct knowledge by tapping into their indigenous knowledge systems. The following is a synopsis of the lecture activities dedicated to training pre-

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service science teachers to teach culturally inclusive science:

Table 1: Work Plan of Part of a PCK module

	Theme	Method of teaching	Resources
	Definitions of IKS	Peer discussion and group discussion to verbally respond to provocative questions	Power point presentation Articles/excerpts from Odora Hoppers and Makhale-Mahlangu (1998).
Part A	Composition of Indigenous knowledge	Peer discussion and group discussion to provide written responses to provocative questions	Selections from article by Onwu & Mosimege (2004).
	Differences and similarities between IKS and Western modern science	Individual interpretation, individual responses to questions	Schematic representation by Barnhardt & Kawagle (2005). <i>Indigenous Knowledge Systems and Alaska Native Ways of Knowing</i> .
	Reasons for and consequences of marginalizing IKS	Peer work: research task Report back to class Class discussion and debate	Internet Journals Community knowledge holders
Part B	Role of the science teacher in facilitating appropriation of indigenous knowledge	Individual responses to questions based on interpretation of an article Application of methods of teaching culturally inclusive science	Article: <i>Rejoinder: Infusing Indigenous Science into Western Modern Science for a Sustainable Future</i> by Corsiglia and Snively (2001).
Part C	Curriculum policy and the Science teacher	Group discussion to respond to question: Describe how Indigenous Knowledge has been made a part of this policy document.	Natural Sciences Curriculum Assessment Policy document Statements

Part D	Science teaching (1) Planning a lesson: cognizance of context and use of resources (2) Teaching Methods (3) Subject content (4) Assessment	Group work to respond to central instruction related to a project: Include knowledge area, specific aims and assessments which apply to the lesson. Describe how you will facilitate learning of the topic. ‘Design a lesson of one hour duration, in which Indigenous Knowledge is integrated. A theme and a topic should be selected from the Natural Sciences learning area. (Refer to the relevant CAPS documents http://talcm.ukzn.ac.za/curriculum.aspx). Describe how learners are expected to construct knowledge about the topic. Include a strategy for assessment. Include all resource materials. Present your lesson as a group. Submit a lesson plan which does not exceed 2 typed pages in length. Submit resource/ assessment pages which are relevant to the lesson’.	Internet Community knowledge holders Policy documents Peers
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Methodology

This study was located in the interpretive paradigm, and sought to understand how pre-service teachers ‘appropriate cultural and social heritages’ (Turuk 2008:245) by means of a qualitative exploration of their written responses to a task (Cohen, Manion & Morrison 2009). It sought to understand pre-service teachers’ choices of knowledge, skills and values when they plan lessons, and relates to Part D, numbers (1) to (4) on Table 1. Convenience sampling was used to admit the responses of 30 pre-service teachers, who volunteered to participate after being informed of the purpose of the study. Cohen, Manion and Morrison (2011) assert that convenience sampling is used to work with participants who are nearby and easily accessible; our participants were engaging with our module on our campus. The 30 pre-service teacher participants were selected because they compiled comprehensive reflective journals, in addition to designing lesson plans which were closely aligned to the module instructions. We engage with documents, namely, policy documents and lesson plans, the latter which were generated by pre-service teachers, as well as pre-service teachers’ reflections, in order to frame the results.

Cohen *et al.* (2009) assert that strong validity is associated with an analysis of documents written for a particular purpose, especially if it resonates with the purpose of the research. They suggest that validity and reliability are able to be enhanced by augmenting the data set with other documents. Lesson plans were used as one set of documents, because they provide insight into the action of teaching. The insight that we as researchers offer in the next section is based on our interpretation of lesson plans to which pre-service teachers have already ascribed meaning. We decided to enhance reliability and validity by using their reflective journals to corroborate findings from the analysis of lesson plans. The pre-service teachers completed their reflective journals, which were semi-structured, to provide an intellectual space in which they could independently reflect on their experiences of learning to teach. This encouraged deep reflection and contributed to their metacognition. The process of reflection enabled participants to make sense of their decisions to teach specific content in particular ways (Moon 2006).

Results and Findings

We explored the following activities of the pre-service teachers, in order to chart their learning to teach culturally inclusive science. First, we explored

what topics/ areas of study pre-service science teachers choose to teach culturally inclusive science, and why they choose these topics; second, the type of learning activities pre-service teachers design for learners to enable learners to learn culture in the science classroom; and third, how pre-service teachers learn to teach culturally inclusive science. Finally, we explored pre-service teachers' views on how they can be enabled to learn to teach culturally inclusive science more effectively.

Each of the groups worked with the CAPS document for Natural Sciences (Senior Phase) (DBE 2011), which comprises four knowledge areas conceptually and progressively linked to subjects in the Further Education and Training (FET) band for grades 10, 11 and 12. The knowledge areas for Natural Sciences are:

- *Life and Living*: linked to Life Sciences in the FET band.
- *Matter and Materials*: linked to Physical Sciences in the FET band.
- *Energy and Change*: linked to Life Sciences and Physical Sciences in FET band.
- *Earth and Beyond*: linked to Geography and Life Sciences in the FET band.

Based on the knowledge area, the participants designed lessons to articulate with Specific Aims 1, 2 or 3 (see Table 2), which are stipulated in the CAPS document (DBE 2011). The profile of the participants and the topics they selected to teach under the category of culturally inclusive science are presented in Table 2.

Table 2: Synopsis of lesson plans and participants

Group	Ethnic group			Specific Aim(s)	Topic	Primary teaching and learning activities (in addition to question and answer methods and class discussions)	Worldview in which knowledge is embedded
	African	Indian	European				

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A	5			1 2 3	Sustainable use of plants as medicine and food	(1) Group work: Match photographs of medicinal plants with a list of uses of medicinal plants (2) Individual work: Read note sheet about medicinal plants. Answer questions based on their uses and sustainability.	African
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B		3	1	1 2 3	Soil pollution and conservation	(1) Group work: Microscopy: Preparation of wet mount of soil organisms (2) Group work: Effect of soil pollution on soil organisms (3) Individual work: Read notes about methods used by farmers in the past to facilitate soil conservation.	European
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C		4		1 3	Tumeric as a medicinal plant	Group work (1) Case study of medicinal properties of turmeric (2) Uses of turmeric by different cultural groups (3) Current uses of turmeric in cosmetic industry (4) Research on health benefits of turmeric by US National Institute of Health	Indian
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D		4	1	1	Indigenous medicinal plants	(1) Group work: research project: Research one indigenous African medicinal plant. Describe its external anatomy, use in the past, present use, including medicinal, and sustainability.	African
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E		5		1 2 3	Nutrition	Group work (1) Analysis of food labels, nutritional value of ingredients listed on food labels (2) Analysis of diets of Indian and African people who lived a century ago, and comparison of these with present day diets. (3) Developing a nutritional vegetable garden at school.	African Indian
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F	3			1 3	Fertilisers	(1) Group work: draw on knowledge from holders of IK and local farmers about use of cow dung as fertiliser. (2) Individual work: Demonstrate how cow dung is prepared to be used as fertiliser. Describe advantages and disadvantages of organic and artificial fertilisers.	African
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G	4			1 3	Medicinal plants	(1) Group work Discuss importance of traditional medicine used globally (2) Answer questions based on the use of Ginseng tea. Discuss side effects of Ginseng. Prepare Ginseng tea.	Chinese
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What to Teach in Order to be a Culturally Inclusive Science Teacher

All the participants in this study selected topics from the Life and Living knowledge area. Groups B and F selected topics associated with the disruption of ecosystems, concerning pollution in general, and chemical pollution (as a result of the use of artificial fertilisers) in particular. Groups A, C, D, E and G focused on indigenous plants as a source of food and/or medicine and healthy living. Central to the plan developed by Group E was healthy living, as it is associated with the alimentary canal, nutrition and a balanced diet. The sustainable use of resources was a common theme underscored by the pre-service teachers.

The participants were guided by curriculum policy, which stipulates the three specific aims in Natural Sciences (DBE 2011: 58-63), namely:

- ‘Specific Aim 1: Acquiring knowledge of Natural Sciences’
The cognitive competencies to assess achievement of this aim are determined by the learner’s ability to recall knowledge, to describe, to analyse and to evaluate.
- ‘Specific Aim 2: Investigating phenomena in the Natural Sciences’
The cognitive skills which are developed are related mainly to practical work, which is of an investigative nature, and which include

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science process skills, such as following instructions, handling equipment, making observations, recording information, measuring, interpreting results and designing investigations.

- ‘Specific Aim 3: Appreciating and understanding the importance and applications of Natural Sciences in society’
The skills developed through this aim can be measured by the learner’s ability to access, describe and evaluate history of discoveries from past and current cultures. An associated sub-specific aim is the relationship of indigenous knowledge to Natural Sciences. The document emphasises two conditions when addressing this sub-specific aim: first, that the examples which are selected should be from practices of the different cultural groups in South Africa, and second, that the examples be linked to the Natural Sciences subject content, which is specified in the various knowledge areas.

Each of the groups expanded on topics in the CAPS document (DBE 2011: 52-79) in order to plan their lessons.

Why do pre-service teachers choose specific topics to teach culturally inclusive science?

Several participants indicated that their choice of topic was contingent on easy access to information, motivation to inculcate healthy eating habits, curiosity about dietary practices of different cultural groups, or resonance with their own culture. The following reflections attest to this:

Group E member: *The members of the group and I found the topic interesting and important. We felt that children in today’s society do not seem to pay much attention to their diets. We also wanted to see what [the] diets of different cultures consisted of, and the reason for their diets [sic].*

Group F member: *It [preparation of fertilisers] is part of my culture. We already knew some things about fertilisers [sic]. Together with my group, we could access information easily.*

An interest in the way in which cultural preference informed the diet of others was what motivated Group E to select nutrition as a topic to study. In addition, they wanted to plan lessons that would impact positively and generate healthy lifestyle choices among their learners. For Group F, familiarity with the topic, together with easy access to information, resulted in their choice of topic.

What Type of Learning Activities do Pre-service Teachers Plan in Order to Teach Culturally Inclusive Science

Each group of pre-service teachers planned extensive group activities for their learners in order to achieve the specific aims. Groups B, E, F and G planned investigative activities that were related to Specific Aim 2. Group B elected to engage learners with microscope work, to enable them to conduct hands on investigations, by preparing and examining wet mounts of soil organisms. They had to follow instructions on a practical worksheet, handle the microscope, observe and draw the organisms in question. Through this activity, the pre-service teachers planned to facilitate knowledge construction of the value of soil organisms in farming; the effect of pollutants on soil organisms and consequently on sustainable farming; as well as examining those sustainable farming methods used by different cultural groups who lived in the past. In this way, these pre-service teachers addressed Specific Aims 1 and 3, and they engaged with indigenous wisdom about natural resource management.

Group E planned a research-based investigation, in which their learners were expected to conduct research by determining the following about planting vegetable gardens: Demarcating a suitable area for the garden; preparing/building the soil; sowing seeds; irrigation; and caring for seedlings. They applied the knowledge of Natural Sciences to society (Specific Aim 3), and sought ways of sustainable food production by learners and for learners. This group emphasised indigenous wisdom in planting crops and selecting food, which formed the diet of past cultural groups. They also aimed to deal with social challenges such as poverty, disease, lack of education, and the effects of these on nutrition, through their teaching. In addition, they adopted an agentic stance by not simply advocating that learners become self-sufficient in food production, but by planning lessons which support learner

empowerment. Group F required their learners to consult with holders of cultural knowledge in their communities, as well as other sources, in order to determine how cow dung can be prepared as a fertiliser. Learners were required to develop steps in the method for production of the fertiliser and develop skills such as measurement, following instructions and observation. Precautions related to methane production and the flammability of methane were also covered. The pre-service teachers in group G designed a traditional practical with recipe-like steps for learners to follow in the preparation of Ginseng tea.

How Pre-service Teachers Learn to Teach Culturally Inclusive Science

Pre-service teachers had to construct knowledge related to two main pedagogical tasks. First, they familiarised themselves with the content of the topic. Second, they designed apposite teaching strategies in order to learn to teach. The participants learnt to teach by tapping into various resources. Several groups were assisted with the content by their ‘elders’, who were traditional knowledge holders. The following reflections describe this:

Group C member: *We did a survey in our local community, targeting elder members as part of the research.*

Group F member: *Elders showed us how to make manure [by][...] mixing old dry cow dung with dried plants. They told us which time of the year to do it.*

Pre-service teachers learned about methods, and seasonal implications, alongside the content, from traditional knowledge holders. Other sources of knowledge were also accessed and applied, as is revealed by the following reflections:

Group C member: *We did research in library books, the internet, and saw what the CAPS document required.*

Group F member: *Working with my group mates [sic], we [shared task of] accessing information.*

Group A: *Through research from the internet we were assisted by fellow group members. We, as pre-service teachers, had a chance to learn how to do an IKS lesson with assistance from group members, whereas, as practicing teachers, we would have been facing this alone in the real situation [sic].*

Pre-service teachers underscored the value of working collaboratively when engaging with the complex task of incorporating IKS into school science lessons. They were able to distribute tasks among themselves and learn from one another; this enhanced their confidence in engaging with IKS in the science classroom.

The participants also drew on their learning experiences from other modules that they had completed, in order to design teaching strategies. The following excerpt reveals this:

Group A: *We learnt how to teach through other modules such as Professional Studies, Learning Area Studies, Natural Science Method 1, and so on.*

How can Pre-service Teachers be Enabled to Teach Culturally Inclusive Science more Effectively?

Several participants emphasised the active role that tertiary institutions can assume to facilitate training of teachers to incorporate culture into their lessons. The following views were voiced by some participants:

Group C member: *Tertiary institutions should offer at least one compulsory module to teach the necessary IKS and ways of teaching culturally inclusive science. [The] government must provide mentorship programs in partnership with tertiary institutions [in order] to assist teachers in using innovative ways to teach culturally inclusive science.*

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Group F member: *I think each and every specialisation module should play its part and [ought to] have a section on indigenous knowledge. Perhaps tertiary institutions could suggest that IKS be examined in the Grade 9 Annual National Assessment tests. IKS should be taught once a week at school level - this would really help, especially because we are running out of fertile land, and [because] aquatic life forms get destroyed due to artificial fertilisers which run off [into water bodies].*

The excerpts reflect the participants' call for training in culturally inclusive content and teaching strategies. The Group C participant viewed this as essential, and therefore suggested the need for a 'compulsory' module. The participant suggested a collaboration between the government and tertiary institutions in order to train teachers who will serve as mentors in teaching culturally inclusive science.

The Group F member called on tertiary institutions to include IKS in all modules. In addition, this participant highlighted the need for IKS to be examined at school level. The participant endorses the need for indigenous knowledge to be taught in classrooms in order to address the challenge of chemical pollution.

This study reveals that PCK modules at tertiary institutions can be designed to enable pre-service teachers to work creatively with curriculum policy documents, while simultaneously embracing practices and concepts located in indigenous knowledge systems. Pre-service teachers can transcend familiar knowledge boundaries by working with multiple knowledge holders, to generate new ways of learning to teach school science. The study shows how a space can be created for pre-service teachers to explore the reservoir of knowledge embedded in cultural diversity and their biological heritage, to plan their lessons. An unexpected finding was the emphasis on self-sufficiency, which was embedded in the lesson designs. Pre-service teachers sought to move beyond incorporating IKS as legitimate knowledge in science classrooms. They integrated indigenous knowledge with science process skills to facilitate knowledge construction about disease prevention and health promotion, and in doing this, designed lessons to empower learners.

Discussion

The lessons developed by the pre-service teachers required them to work in unfamiliar terrain, to look to unconventional sources for designing their lessons, and to broaden their epistemological and pedagogical horizons as teachers of school science. They engaged in ‘previously unknown ways of conceptualizing phenomena in the world’ (Turuk 2008:245). The participants interacted with members of their groups, community holders of cultural knowledge and the lecturer, and appropriated knowledge related to teaching culturally inclusive science. They learned to teach collaboratively, because their learning was assisted and mediated by members of their group.

Pre-service teachers selected topics in the Life and Living knowledge area because these topics were socially meaningful. Education for relevance accompanied by education for self-reliance, such as that proposed by Julius Nyerere (Kaya 2012), underpinned the work of the participants. The pre-service teachers revealed their potential as African intellectuals, who were able to incorporate IK into western science lessons, and apply skills learned in western science education to use IK to address social challenges.

Teachers’ greater familiarity with western science over that of IKS is attributed to their training (Ogunnyi 2007). This results in teachers drawing on the thought systems of western science when they design lessons. This study has revealed how a teacher training module may be developed in order to address teachers’ inadequate views, especially of IKS. The module was developed to enable pre-service teachers to look for ways in which the two systems of thought (western school science and IKS) may be used to complement each other, in order to successfully implement what Ogunnyi (2007:963) refers to as ‘Science-IKS curricula’. Aikenhead and Ogawa (2007) assert that the terms IKS and Science are used in overly simplistic ways, and that this conceals the similarities between the two systems of thought. The PCK module described in this article reveals how pre-service teachers may be supported in reconciling aspects of both systems of thought as a route toward effective and relevant teaching. This resonates with the view expressed by Aikenhead *et al.* (2007:540) that ‘science educators [ought to] build bridges between their own Eurocentric knowledge systems and other ways of knowing.’ Instead of viewing indigenous knowledge systems and those which are embedded in western science as ‘disparate’ (Nakata 2007) or impossible to reconcile (Russel 2005) pre-service teachers were supported by

one another as well as by the module task, to design lessons which draw on *both* systems of thought in a complementary way.

Conclusion

This study argued for pre-service teachers to re-think how they learn to teach by recognizing IKS as legitimate and valuable in the science classroom. It reveals how pre-service science teachers, when directed by relevant instructions, can become enabled to disrupt the linearity of thought and practice, to move beyond the familiar pedagogical boundaries into new spaces, and to learn to integrate IKS in their lessons. Given the intellectual space and opportunity, pre-service teachers can be guided to explore how indigenous knowledges can be taught in the science classroom. Multiple sources of information can be accessed from written information and people who are holders and practitioners of cultural knowledge. This form of collaboration can facilitate learning across generations, and can engender a new respect for indigenous knowledge, especially among young people.

It was observed that the engagement of participant pre-service teachers in activities that call for them to think deeply about how they teach, conscientised them about the value of IKS. It enabled them to advocate for a more serious consideration of IKS in school and university curricula, which are based on policy. Their call for indigenous knowledge to be examinable at national level, and for the compulsory inclusion of IKS at tertiary institutions, has implications for policy makers in education. Science teacher educators at tertiary institutions need to develop modules which include IKS in order to equip teachers to implement the science curriculum more effectively. It is crucial for teacher training institutions to recognise teachers as fundamental agents in the process of implementing school curricula. This study reveals ways in which science education programmes can be designed in order to enable teachers to meet the needs of the new curriculum. Articulation of university curriculum policy which informs modules intended for pre-service teachers, with school curriculum policy, is crucial to the effective teacher training process. The practice of university educators, which, when informed by appropriate learning theories, such as Vygotsky's sociocultural learning theory and ZPD, has the potential to enhance pre-service teachers' ability to deliver a culturally inclusive curriculum.

It is upheld here that effective, apposite teacher training programmes can promote the epistemological decolonisation of African people, by supporting them as they navigate new ways to bring IK into the mainstream of knowledge production in Africa. A reconnection with IK can lead to the restoration of the African identity into one which is self-sufficient, self-aware, proud and powerful.

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