Science Teachers' Indigenous Knowledge Identities

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Abstract

The purpose of this study is to report on science teachers' indigenous knowledge (IK) identities, in relation to the teacher professional development program whose aims were: to research IK, to produce teaching and learning materials on the integration of IK and science, and to introduce pre-service and in-service teachers to the construct of multicultural science learning and teaching environments. The formation of a teacher identity in multicultural science teaching environments is a complex construct because of the existence of the multicultural environment. It is important to understand the effectiveness of the current teacher preparation and professional development programs; these have important implications for educational success, access to education, and the effectiveness of such education, which could ultimately lead to sustainable development in developing countries. The trajectory of the transition of science teachers' IK portraits and formations, based on the findings of this study of six teachers, provides a rich yet sobering account of the potential challenges and pitfalls that teachers working with multicultural science classrooms.

Keywords: indigenous knowledge; western science; communities of practice

1. Introduction

In response to increasingly challenging curriculum expectations and growing diversity among students in science education, a number of curriculum development initiatives and professional development programs have emerged. Recent lines of research in the past decades have shown a shift towards promoting alternative approaches to education for sustainable development. This has led to a growing consensus that some of the challenges facing developing countries, in particular South Africa, could be resolved by solutions from within the local context (Aikenhead, 2001; Owuor, 2007) rather than being imposed from the outside. In this study, we propose that indigenous knowledge (IK) can be recognised as one way of dealing with the challenges in a sustainable manner, by acknowledging the role of IK and its practices in developmental projects. The term 'developmental project' is used broadly here to refer to projects in education, conservation, agriculture, and technological innovations, to name but a few. However, for the purposes of this study, we examine the concept of IK in relation to teaching and learning in science education.

In many Sub-Saharan African countries, there is an inherent tension between Eurocentric Western Science (WS) and the IK of African students, both of which are products of their respective socio-cultural constructs. These two worldviews, when experienced by students in science classrooms, are often different; if not properly mediated during science lessons, this could potentially lead to "complicating the learning process and potentially resulting in cognitive conflict or, as the literature describes it, cognitive dissonance/perturbation" (Le Grange, 2007, p. 581). While the inclusion of IK in the science education curriculum is welcome, in that it provides a platform, where WS and IK can interact, science teachers will have to adapt their teaching in order to realign with the demands of such integration. This requires transformation of teachers' IK and their professional identities since their current training as teachers does not take into account teachers' IK, nor does it consider the IK of their students. In order to narrow the gap between WS and IK in science education by integrating these two knowledge systems, it is necessary to create new curriculum initiatives which delineate what IK should form part of the curriculum, establish teacher professional development programs which focus on implementing the new curriculum which incorporates IK, and encourage more research in the field of IK in science education. One such teacher professional development program is presented here as a community of practice (COP).

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Many studies, carried out in countries as diverse as New Zealand, Australia, Kenya and South Africa, among others, have identified the role of IK in science education as critical (National Curriculum Statement, 2002, 2011; Ninnes, 2000; Ogawa, 1995; Ogunniyi, 2000, 2007; Owuor, 2007). Before looking at the implications of including IK in science education, it is necessary to define IK. According to Odora Hoppers (2005, p. 2), IK refers to: "the sum total of knowledge and skills which people in a particular geographic area possess, and which enables them to get the most out their environment". This definition is not exhaustive, but the conceptualisations associated with IK in the literature do have some degree of consensus in defining it as a peculiar knowledge system that is inherent to a particular group of people confined to a unique geographic area, and that enables them not only to survive but to become a civilised community (Maila & Loubser, 2003; Ntuli, 1999; Ogunniyi, 1988, 2004, 2007; Vilakazi, 1999).

In many African countries, however, opponents of the inclusion of IK in science education and its values, argue that IK refers to the historical and ancient practices of African people which are illogical, outdated, and is no longer relevant to today's world and today's science education curriculum – we do not share this view in this study. Instead, we posit that IK is embedded in both historical and current practices, which are unique to people in a specific geographical area and is still sustaining the majority of rural populations in Africa. Owour (2007, p. 23) similarly defines IK as a learning process: in other words, it *"is a process of learning and sharing social life, histories, identities, economic, and political practices unique to a cultural group"*. In addition, IK is also perceived as an alternative informal form of knowledge, which includes indigenous science, such as ethno-mathematics, ethno-medicine, and ethno-botany, among others (Horsthemke, 2008).

As noted above, the dilemmas and contradictions that arise from the integration of WS and IK in science education are complex, not only in terms of curriculum transformations but also in terms of teacher education and pedagogical practices within science lessons. These challenges are not experienced by students only, but by teachers and curriculum designers. There is a growing acceptance of the need to integrate WS and IK to promote multicultural science learning environments in schools. In South Africa, for instance, the National Curriculum Statement in the Further Education and Training Phase states that: "In Physical Sciences learners are required to research, discuss, compare and evaluate claims made by Scientific and Indigenous Knowledge Systems [IKS] by indicating the relationship between them (scientific concepts and IKS)" (Department of Education, 2005, p. 10). This quote mentions learning outcome three (LO3) which puts emphasis on the integration of WS and IKS in the science curriculum. In order for science teachers to affectively achieve learning of LO3 in their teaching they need to be exposed to IK based experiences/conceptions in science education professional development programs the same way they do with WS, and teaching materials on the integration of WS and IK should be made readily available; likewise, new paradigm shifts on teaching and learning of WS and IK have to be created. This study thus reports on the formation of teachers' IK identities in relation to the teacher professional development program, whose aims were: to research IK, to produce teaching and learning materials on the integration of IK and WS, and to instruct pre-service and in-service teachers on multicultural science learning and teaching environments. Therefore, the research question of this study is: What are the science teachers' IK identities that are developed during a professional development program - this professional development program is a COP? Throughout this study, the acronyms 'IK' and 'IKS' are used interchangeably to refer to indigenous knowledge and indigenous knowledge systems. In addition, the word 'identity' refers to a person's "beliefs, attitudes, emotions, and disposition" (Grootenboer and Zevenbergen, 2008, p. 243) towards IK, WS, and their role in the science education curriculum.

2. Theoretical Framework

The central foci of this study are science teachers' IK identities and their professional development through a COP. Before discussing teacher identity, however, we focus on the definition of identity by Bishop (2012):

I define identity as a dynamic view of self, negotiated in a specific social context and informed by past history, events, personal narratives, experiences, routines, and ways of participating. An identity is who one is in a given community, and as such, is both individually and collectively defined (p. 38).

From Bishop's (2012) definition, we note that identity is not something a person is born with, but rather something that develops as an individual interacts socially over time; moreover, these social relationships could focus on the past, the present, or the future. In addition, identity is not a fixed attribute of an individual; rather, it is framed by external factors, such as historical and current events, and the socio-cultural activities to which individuals are exposed, and it encompasses affective notions, such as feelings, beliefs and attitudes (Bruner, 1994; Cheung, 2008; Gee, 2001; Wenger,

1998). In sum, Holland et al. (1998, p. 3) posit: "These self-understandings, especially those with strong emotional resonance for the teller, are what we refer to as identities". Drawing heavily on the definitions of identity espoused by Bishop (2012) and Holland et al. (1998), I use the phrase science teachers' *IK identity* to refer to the ideas, often tacit, that science teachers have with respect to IK and its science teaching activities particularly in relation to multicultural learning and teaching in science education. It is imperative to note here that this notion of IK identity encompasses teachers' own ways of talking, acting, and being as well as the ways in which other teachers position them with respect to IK.

We already noted that science teachers' IK identities are developed through social interactions. In this study, a COP known as the Science and Indigenous Knowledge Systems Project (SIKSP), as a means of professional development, was used to foreground science teachers' IK identities. According to Wenger (1998), "*Communities of practice are a group of people who share a concern or passion for something they do and [who] learn how to do it better as they interact regularly*" (p. 1). The SIKSP group as a COP is made up of science teachers, teacher education facilitators, science education students, researchers in science education and individuals whose interests lie in science education. The members of this COP thus share a common interest that centres on the integration of WS and IK in multicultural science environments. In addition, its aims are: to produce teaching resource materials for science teachers, to create awareness of how IK and WS can be integrated, to build IK data archives that could be used by science teachers as resources around the country, and to use postgraduate research as a vehicle to deepen their understanding of multicultural science learning and teaching environments. We are aware that the construct of multicultural science is broad; however, for the purposes of this study, it refers to the integration of WS and IK in science lessons, and uses argumentation as an instructional strategy, namely, as a way of evaluating scientific claims, challenging, backing and rebutting them (Toulmin, Rieke and Janik, 1984; Toulmin, 1958).

The transition from teaching science in WS contexts to one where it is necessary to include IK contexts require science teachers to form new identities with regard to these worldviews. In this study, thus, Wenger's (1998) view of identity as a mode of belonging was used to analyse the science teachers' IK identities. According to Wenger (1998). there are three modes of belonging in a COP, namely: engagement, imagination and alignment. We used these three modes of belonging to make sense of the IK identity formations of the six science teachers who participated in this study (Au, 2002; Moje & McCarthy, 2002). Engagement is about the "active process of involvement in [the] mutual process of negotiating meaning" (Wenger, 1998, p. 173). In the context of this study, engagement refers to science teachers' participation in the activities of the COP, such as: attending seminars on the nature of science, WS versus IKS, developing teaching and learning materials on multicultural science, and engaging in postgraduate studies. Participating in some or all of these activities creates a sense of belonging. Imagination is about expanding the images of self among the COP members so that they extend beyond their immediate context and time, for example, by ensuring that local activities in the COP deal with other enterprises beyond the science classrooms, such as: teachers' professionalism, social justice issues in communities, sustainable development projects based on medicinal plants, agriculture conservation, to name but a few. Alignment refers to "co-ordinating our energy and activities in order to fit within broader structures and contribute to broader enterprises" (Wenger, 1998, p. 174). This means that the activities of the COP, such as teacher professional development, should not be divorced from, but rather contribute towards the goals of similar enterprises. Research has shown that "today's teacher preparation programs are usually not well equipped to prepare a new generation of reform-minded science teachers" (Luehmann, 2007, p. 822) to deal with, for example, multicultural science, learning and teaching. This challenge, we argue, could be resolved by using identity development as a theoretical lens. Drawing on Bishop's (2012) definition of identity, we concur with Luehmann's definition of teacher identity as being, "recognised by self and others as a kind of person because of the interactions one has with others" (Luehmann, 2007, p. 827). Teacher identity formation in teacher education is a means of learning, in which individual teachers become full participants in learning within a COP. It must be stressed here that participation is central for teacher learning in a COP: in other words, it is through participation in the activities of the COP that teachers construct their own identities of belonging, which may or may not align with the goals of the COP. The decision as to whether an individual teacher participates or not in the activities of the COP and/or in any reforms related to it, such as reforms in science education, is influenced by the acquired teacher identity - meaning that identity formation has significant implications for teacher participation and learning in a COP (Akkerman & Meijer, 2011; Chauraya, 2013).

3. The Study

This study was conducted at a university in the Western Cape Province in South Africa over a period of three years; the results reported herein with regard to science teachers' IK identities are based on reflections of the participants from the

SIKSP members, which we have already discussed above / previously. Although all the members of the SIKSP group participated in this study by responding to a questionnaire that required them to reflect on their participation in the activities of the SIKSP, this study only discusses the reflections from a target sample of six teachers. These six members, who had been with the SIKSP for at least three years, were selected from twenty-three COP members of the SIKSP and were all given anonymous designations, namely, T01, T02, T03, T04, T05 and T06. Of the six members, one (T05) is a white woman of European descent who had joined the SIKSP because she valued several of the IK practices, which she saw and experienced when she was growing up; as a result, she was particularly interested in folklore. Another woman (T03) was a black African, and the remaining four participants were black male Africans – of which two were South Africans, one was Kenyan, and the sixth one was Cameroonian. Since all six participants have been involved in teaching science at schools in their careers, in this study we refer to all of them as teachers. For the purposes of data collection, the participants responded to open-ended questions on the issues of preparing teachers for the implementation of a multicultural science curriculum, driven by both WS and IK, and preparing them to conduct research in the field of IK. In addition to analysing the reflections of the six participants, we also looked at the reflections of other members of the SIKSP groups in order to strengthen our arguments – although this data was not part of the overall results.

Ogunniyi's (2007) contiguity argumentation theory (CAT) was used as a framework to critically analyze teachers' identities as perceived through their reflections, which were divided between two different subheadings, namely: science teachers' IK identities at the beginning of their COP activities, and science teachers' IK identities after participating in the activities of the SIKSP. The CAT is underpinned by the mechanism of internal conflict resolution, which occurs when individuals are confronted with worldviews that conflict with their own. CAT stems from the Platonic and Aristotelian era: "The Aristotelian Contiguity Theory asserts that one or two states of mind (or as applied in the CAT, two distinct coexisting thought systems, e.g. science and IKS), tend to readily couple with, or recall each other to create an optimum cognitive state" (Ogunniyi, 2009, p. 173). In other words, CAT is a learning theory, which asserts that, for meaningful learning to occur, new ideas and ideas that already exist within an individual's cognition / cognitive frame of reference must have some form of commonality. If there are disparities, several responses are possible, internally or cognitively. when an individual is introduced to new culture, in this case, WS/IK. These are: conflict, which can lead to rejection of the new view; co-existence or assimilation, if the new idea is slightly linked or similar to the predominant view which leads to integration into the existing milieu and harmonization, (Ogunniyi, 2013). For harmonization and adaptation to occur, Ogunniyi's CAT asserts that a common ground between the dominant (IK/WS-based) worldview of the participant can be reached through negotiation, both through interpersonal and intrapersonal dialogue. In this study, the conflicting views are either WS or IK, depending on the socio-cultural backgrounds of the participants. CAT is underscored by equality, meaning two opposing worldviews on certain thought systems can only be validated when given similar status initially. Thus Ogunniyi emphasises that "the claims and counter-claims [rebuttals] on any subject matter within a field e.g. science or IK...can only be justified of course if both systems of thought are initially accorded the same status until one is found to be inappropriate for a given context," 3013, p. 18. Ogunniyi's CAT comprises five cognitive conceptions namely, dominant, suppressed, assimilated, emergent and equipollent according to which a participant may shift her/his conceptions about nature. A dominant cognitive conception is an individual's guiding principle on particular thought systems. If we have two cognitive conceptions one of the two could be suppressed by the one which is more acceptable. Whereas an assimilated cognitive conception arises when an individual acquires a thought system and use it accordingly with own. An emergent cognition develops after exposure to a new concept for a first time, and an equipollent state has equal mental power within an individual's conceptions. These conceptions are what we will use to analyze the members in a COP. Conceptual shifts happen intrapersonal or interpersonally as people engage on different issues for instance on curriculum issues. Ogunniyi and Hewson (2008, p. 162) state:

A cognitive stage is dominant if it is the most adaptable to a given context; a cognitive stage becomes suppressed by one that is more adaptable; a cognitive stage becomes assimilated into one that is more adaptable than itself; an emergent cognitive stage occurs when one is exposed to a phenomenon for the first time, with no previous knowledge of it; an equipollent mental stage occurs when two opposing ideas or worldviews exert approximately equal intellectual forces on the person.

In addition, we have also used a tag (or word) cloud as a tool for preliminary analysis and as a tool to confirm and validate the findings, and the interpretations of the findings. A tag cloud is a visual array of content tags, in which tags with a higher frequency of appearance are usually identified with larger fonts, or emphasized in bold or by using different colors. This method was applied to the participants' responses with regard to their beliefs on the IK-related activities of the SIKSP at the beginning and at the time reflections were done by members of SIKSP. Such a tag cloud gives a quick

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and easily scanned visual preview of what groups or individuals are saying, thinking, doing or interested in, in this case, with regard to science teachers' IK identities in relation to a professional development program (Bateman et al, 2008; Heast & Rosner, 2008; Sinclair & Cardew-Hall, 2008). Proponents of the use of tag clouds argue that the "main benefit of tag clouds may be to show the presence of activity" (Christie et al., 2010, p. 360). In addition, we argue that tag clouds also show the intensity and importance of activity.

4. Findings

The following section discusses the findings obtained with regard to the science teachers' IK identities, divided into three sections.

4.1 Science teachers' IK identities at the beginning of SIKSP activities

The following tag cloud was generated using *worditout* (see www.worditout.com). It is generated from the responses of six teachers who participated in the study. All of them were asked: "*What were your beliefs about IK, WS, and IK research at the beginning of the SIKSP activities?*" A quick glance at the tag cloud reveals the most frequently used words in the responses from the participants, as these words can be identified with larger font sizes, viz. 'IK', 'backward', 'science', 'activities', and 'worldviews', in decreasing order of frequency. The prominence of the word 'backward' in the tag cloud is key to illustrating the participants' beliefs about IK at the beginning of the COP activities. Using the CAT to analyse the teachers' dispositions about IK, we can say that, at the beginning of the professional development program, the dominant assumption among teachers was that IK was 'backward'.



Figure 1: Tag cloud of the participants' beliefs about IK at the beginning of the SIKSP activities.

Other less prominent words from the tag cloud also depict negative perceptions; they include words such as: 'uncivilised', 'irrelevant', 'lagging' and 'Eurocentric', among others. At the beginning of the SIKSP activities, the teachers' reflections revealed various beliefs that they held about IK; Table 1 gives a summary of these themes, emerging from these beliefs. 67% of the teachers perceived that IK was the reason why the African continent was 'backward' or 'behind' in development, and that therefore integrating IK with school science which is predominantly WS would maintain the underdevelopment of the continent. This finding concurs with that of the tag cloud. It was also confirmed by the statements from participants; for instance, T01 said that, "I saw it [IK?] as being uncivilized and a let-down for black people. I could not imagine advocating for the use of anything indigenous from clothes, food to medicine etc." Similarly, 33% of the participants in the study perceived that IK was solely for the use of uneducated people, and thus could not see why it should be brought into the school curriculum. 50% {3} of the six participants believed that Eurocentric science (or WS) was the only authentic form of science because school science consisted only of WS. Participants T1, T2, and T4 also viewed science as 'special,' from 'outer space' and done by 'unique people'.

 Table 1: Teachers' beliefs about IK and WS at the beginning of the SIKSP activities

Emerging themes
IKS is backward; therefore it should not be brought into African schools, otherwise the continent will lag behind forever;
IK is for the uncivilised people and an embarrassment;
Eurocentric Science is so special and the only sound and empirical science, done by unique people from developed countries;
Valued IK because of my childhood experiences;
Joined the SIKSP for own interests;
Valued the ecological knowledge of IK holders from my communities since childhood;

The aforementioned beliefs are held by five African black participants. Only one of the participants valued IK at the

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beginning of the SIKSP activities. This member is retired and a white female with over 40 years of teaching experience at college and at university in teacher education. She said that she valued the ecological knowledge of indigenous people with regard to their local environments, their knowledge of herbal medicine and their ability to predict local weather. This stems from her childhood experiences of a family caregiver who was an accomplished storyteller - the caregiver was a black nanny. The dominant negative perceptions about IK, as reflected by the majority of the participants, attests to Jegede's (1997) argument on the effects of non-contextualised school science for non-western learners, namely, "a pervasive view held by a large proportion of African society that the study of science is something special in that it requires magical explanations incompatible with the thoughts of someone from a non-western society" (p. 10). This according to Jegede leads to compartmentalisation of knowledge, whereby what is learnt at school such as school science is not applied to everyday living but kept as academic knowledge.

On the other hand Kozulin (2003) opines that the use of prior knowledge in learning new concepts supports and complements logical thinking. Hence, for most non-western learners, science tends to be assimilative in nature for most learners, particularly when such learners are supported by family, community, science teachers and for individuals who have intrinsic motivation to receive a good education and presumably a better life. Contrarily for some learners, school science conceptions can be far more discordant experiences for learners who lack such support (Carlone and Johnson, 2007; Ogunniyi, 1988). For this reason, learners whose frameworks about nature are predominantly non-western may need some form of bridge to help them link their prior knowledge to the new concepts being brought about in science.

In sum, at the beginning of the COP activities in the SIKSP, five of the six (5/6) participants' dominantly identified themselves with a WS-based worldview and regarded IK-based worldviews as 'backward'.

4.2 Science teachers' IK identities after participating in COP activities

After participating in the activities of the SIKSP, the six teachers showed significant shifts in their identities with regard to IK, WS, and science curricula. The tag cloud in Figure 2 shows the beliefs of participants about IK and WS after engaging with the SIKSP activities; as before, *worditout* was used to create this tag cloud. Participants were asked: "How did the activities of the SIKSP influence your beliefs about a multicultural science education curriculum, in other words, a curriculum that integrates IK and WS?"



Figure 2: Tag cloud of the participants' beliefs about IK and WS after engaging with the COP activities.

At a glance, it can be seen that the tag cloud shows emphasis on the following words: 'science', 'IK', 'awareness', 'multicultural', 'integration', 'enables' and 'supports', among others. We can use these words from the tag cloud in Figure 2 to make comparisons with the emerging themes about the beliefs of teachers with regard to IK and WS, after they had engaged with the professional development program.

 Table 2: Teachers' beliefs about IK and WS after engaging with COP activities

_ Emerging themes
Got freed from the bondage of thinking that only WS has all the solutions to human problems
Some science concepts can be taught from IK. There is science in IK.
NOS & NOIK is eye opening ; multiple worldviews valuing IK, e.g. practices around food and herbal medicine
Knowledge acquired from the SIKSP informed my decision to do research in IK
Became aware of multiple worldviews through the SIKSP
Believe in multicultural sciences
Science is invasive, therefore it must be taught within learners' social-cultural context
Science is a human enterprise, and it is contextual
Science has limitations just like IK
Science can be interpreted and driven by people with different agendas: political, economic and social
Successful integration of IK and WS should focus on in-service teacher training – a change of mind-set with regard to IK

Table 2 shows that, through engagements with the activities of the SIKSP, 50% of the participants attest to having broken down the incorrect assumptions they had held previously with regard to their IK, and which had led to them undermining and denigrating their own cultural practices. This is in accordance with Jegede's (1997) assertion of the dissonance which school science seems to create in learners' ways of interacting with nature when science is not contextualised. Ogunniyi (2013) asserts that, two different thought systems can co-exist when they share common elements within an individual due to the brain's ability to correlate. Participating in the discursive activities of the SIKSP, which include, but are not limited to, exploring the use of dialogical argumentation (DA) as an instructional method, the nature of science (NOS), and the nature of indigenous knowledge (NOIK), all created awareness with regard to valuing a multicultural science approach to science education. After engaging in such activities, 5 out of 6 of the participants changed their original views towards IK, and came to believe that IK practices should be part of the national science curricula. T03 stated that:

There is much that science and development in technology has achieved at the expense of other cultural worldviews rather than enabling the different viewpoints to merge; western science [WS] had an invasive characteristic. It makes participants and those who are exposed to it to disregard their beliefs and to view them as inferior, especially so on the African continent, which was colonised culturally, morally and physically, thus stripping Africans of their customs of community spiritedness and destroying family bonds.

Meyer and Crawford (2011) argue that, engaging participants especially prospective teachers in NOS activities participants develop the understanding of scientific conceptions and the 'culture' of scientists in their COP. In the same vein they argue that science as a culture has its own characteristics and rules therefore, it should be explicitly taught. Echoing Meyer and Crawford (2011), and after engaging in NOS and NOIK, T04 stated as follows:

More so, I am also able to mediate the science-IK discourse within a classroom environment where I can project a more valid view of science, its benefits, and its limitations as well as being able to point out its detrimental effects on society (e.g. through awareness of socio-scientific issues).

After participating in the activities of the COP, the teachers showed a willingness to achieve alignment – using Wenger's (1998) mode of belonging, thus incorporating what they had learnt in their COP into their daily professional practices. Using CAT, all the participants 6/6 (100%) acknowledged that they were at equipollent stage, where they viewed both WS and IK as equally valuable. It is worth mentioning that teachers' multicultural views of science were influenced by their participation in NOS and NOIK activities presented as a teacher education course module (Ogunniyi, 2008).

4.3 Reflections on IK postgraduate research and conference presentations

Part of this study also looked at the teachers' identities through their reflections, as they embarked on their research activities during the time that they were participating in the SIKSP activities. We have already mentioned that, through engagement in a COP, SIKSP offers and creates enabling environments for teacher development that promotes the emergence of new identities through practices at work and also in their personal lives. IK research promoted such an environment, where members of a COP could conduct research on IK activities beyond the implications of incorporating IK and WS in science classrooms. 83% of the participants were doing science-IK related research at the time of their participation in the SIKSP activities – this included postgraduate research and/or general research in IK. The outputs of such research were usually presented by means of dissertations/theses, and/or the publication of findings in journals and/or the presenting of research findings in conference proceedings, as well as discussing them during workshops and seminars at the SIKSP sessions. Five out of the six participants reflected that these seminars and workshops informed their research into science-IK related studies. T05 posits:

IKS research activities have helped me to realize the truth about the nature of science. It has helped me to realize that science is a human activity and that it is formulated and interpreted by people with all sorts of agendas: political, economic and social. As such, IKS has the same validity, regardless of what orthodox scientists may think.

One of the participants acknowledged that his thesis which involved the teaching of grade 11 concepts of sound through making references to IK was a huge success due to support from SIKSP activities. This approach of teaching sound concepts using indigenous artefacts was ground breaking for him given that his school experiences made no attempt to include IK in the teaching of science concepts. His thesis was based on the use of an argumentation

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instructional model in teaching grade 11 learners certain concepts of sound by making use of indigenous musical instruments. By engaging in various activities that involved argumentation and research, the teachers came to understand science as a human enterprise with its own shortfalls. This view emerged because, at the beginning, 4 out of the 6 participants viewed science as the answer to all human problems. According to TO3:

Besides, that [IKS] it made me reminisce about my growing up and all the herbal medicines that my mother used to give us for prophylactic purposes, which I cannot pass on to my children because I thought using herbal medicines was backward ... I wish I could regain that knowledge and pass it on to my kids.

After engaging in the SIKSP activities, however, T01 and T03 proudly purchased traditional food, African artefacts and medicines, and sought to regain their knowledge of traditional remedies, in order to be able to pass on this knowledge to their own children so explicitly. What is important to note here is that T01 and T03 both came to realise that IK did have a role to play in their individual lives; this is critical, in the sense that sustainable development programs driven by Western countries in developing countries, tend to downplay, even denigrate and suppress, the IK of local people. Due to this tendency, most development programs that are meant to sustain indigenous people tend to collapse, as soon as they are handed over to the beneficiaries, because they are imposed on the people. However, we posit that, in order for any of these sustainable development programs to yield the intended results, namely, to improve the quality of lives of indigenous people, and then there should be deliberate recognition of the IK of people from the start. The members of the COP acknowledged the contributions made by WS worldviews, but also pointed out that the current degradation of the environment was partly due to greed, which had led to the over-usage and depletion of natural resources. This situation could be ameliorated, if indigenous ways of conservation were practiced. Clearly, then, IK has an important role to play in education for sustainable development, while improving the quality of lives of people in developing countries, and in particular, those living in rural areas and in marginalised communities.

5. Conclusion

This study has drawn attention to questions about COP and identity formation that are encountered by individuals during transition periods in their professional lives as science teachers teaching in multicultural environments. In this research, we have seen that science teachers have more than a passing intellectual interest in their conceptualisation of NOS and NOIK. The IK and WS teacher identity portraits found in this study illuminate and speak to possible challenges and pitfalls that are likely to be faced during the implementation of a multicultural curriculum in science education – indeed this may have huge implications on the ways in which science education, and in particular teacher education, should be structured to cater for new curriculum changes and for the realignment of professional development programs, during both preservice and in-service phases. Recent lines of research support the beliefs that the identity that teachers construct plays a critical role in changing education policy landscapes, such as: curriculum changes, learning and teaching, mandated assessments, and the ways in which teachers' professional development can be coupled with their commitment to teaching as a profession (Beijaard et al., 2004; Enyedy et al., 2006; Robinson & MacMillan, 2006).

We believe that teacher education research has the responsibility to improve schooling in marginalised and diverse communities. Improving the quality of teacher education requires a paradigm shift away from the conventional 'best practices' of teacher education and professional development. This shift should lead to new practices that are aimed at servicing diverse communities and that are "*less abstraction and more concrete involvement and interaction with the community itself*" (Au, 2002, p. 226). Teacher education facilitators, for instance, in higher education institutions, in schools, in mentorship programs, and in other programs responsible for pre-service and in-service teachers, should seek and encourage the formation of teacher identity by facilitating teaching and learning activities, such as reflecting on practice and empowering decision making through action research, thus leading to the creation of a positive and personally meaningful teacher identity, since this empowers teachers to "*explicitly build upon and challenge their experiences and beliefs*" (Washington, 2005, p. 63). We posit that this is a departure from the traditional methods of practices, which were intended to focus on the assessment of performance and on grooming teachers for the teaching profession. Focussing on teacher identity formation developed within a specific context – e.g. a COP dealing with teacher professional development – – can lead to the development of teacher skills and an increase in confidence to make decisions that are aligned with reforms in science education. In sum, we acknowledge that learning through participation in a COP encourages collegial relationships that nurture and develop individual teacher identity.

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