Re-envisioning Pedagogy for African Higher Education: Students' Status of Science and IKS via Argumentation Discourses

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Abstract

The study explored the effects of an intervention strategy underpinned by the Contiguity Argumentation Theory (CAT) and Ogunniyi's Practical Argumentation Course (PAC) designed to shift students' perceptions towards science-IKS being equipollent (equal cognitive status) in a module that focused on re-envisioning African Higher Education. Eighty-five (85) primary science preservice students in a Natural Science Method module took part in the study. The module exposed students to the Nature of Science and IKS including the indigenous practices of African communities. Students' status of science-IKS from pre- and post-questionnaire were compared and validated by individual interviews where they deliberated the status of indigenous and scientific knowledge. During focus-group interviews, students argued whether classroom implementation of IKS has value or not in achieving the goals of science education. The analysis of data indicates that students' CAT status, after PAC intervention, shifted from Dominant, Suppressed and Assimilated to more Assimilated, less Suppressed, some Emergent and a few Equipollent. The findings also suggest that students have a more nuanced understanding of the status of indigenous knowledge and its relationship to science that was developed through the dialogical argumentative discourse supported by curriculum resource materials. The findings imply that educators need to engage students explicitly in using instructional strategies like argumentation discourses for a sustainable duration while incorporating students' local, cultural and indigenous experiences in addressing the science and social-justice goals of education.

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Introduction

There have been several studies both in Africa and worldwide calling for tertiary teaching institutions to develop culturally-sensitive strategies that interface science with the local knowledge and beliefs of their students (Aikenhead 2001; Brown, Muzirambi & Pabale 2006; le Grange 2008; Webb 2013). Often African students are taught science and other subjects in westernized classrooms in the absence or denial of their cultural and indigenous experiences. The lack of understanding and the exclusion of students' African knowledge pose learning difficulties for these students, as it is difficult for them to make sense of abstract science in the way it is taught currently. It is also an educationally complex process to integrate their scientific worldview in terms of their African cultural experiences when crossing cultural-borders. To surmount these difficulties, there is a growing call for pedagogic intervention and support to resolve conflicts arising between science and indigenous knowledge (IK), especially where science is recognised as the dominant knowledge that exerts a powerful, political and universal influence (Abrams, Charles & Guo 2013; Ogunniyi & Ogawa 2008; van Wyk 2002). In particular, in post-apartheid South Africa, there is also an urgent need to address social injustices.

In addressing the above issues and transforming the education curriculum after apartheid, the Department of Basic Education in South Africa (DOE 2011) has included indigenous knowledge systems (IKS) in the school curriculum which emphasises valuing and 'acknowledging the rich history and heritage of this country as important contributors to nurturing the values contained in the Constitution…' (p. 5). While the Department of Science and Technology (2004) has policies regarding the promotion of IKS, and 'a strong drive towards recognizing and affirming the critical role of IK' (p. 18), there is little evidence that the goals of these policies are being achieved on a large scale in both school and tertiary education, except perhaps, at a few universities where IKS modules are offered.

With regard to the role of IKS in relation to science, instructional strategies such as argumentation serve as a critical dialogical teaching and learning tool that has thus far been successful in engaging students and teachers in controversial and reflective issues (Erduran & Jim´enez-Aleixandre 2007; Msimanga & Lelliott 2012). Argumentation theory and discourses as espoused by Ogunniyi's (2006) Contiguity Argumentation Theory (CAT) and his Practical Argumentation Course (PAC) provide valuable theoretical underpinnings and successful instructional strategies from research for students coming from indigenous backgrounds. It was anticipated in this study that PAC as an instructional strategy can inform and enhance preservice students' critical and reflective understanding of the stature of science-IKS and shift their status of science-IKS towards equipollent status. There was also a possibility of transfer of argumentation skills developed in this course to other contexts (Ogunniyi 2007a; 2007b).

This study thus explored the effects of an intervention strategy via PAC argumentation discourses when students' engaged in science-IKS issues in a module that focused on re-envisioning education for African Higher Education. It also intended to conscientise students about the wealth of African culture, and to create opportunities in the tertiary classroom to deliberate and integrate scientific and African traditional world-views and practices. It was envisaged that an argumentative discourse that is culturally relevant would make students aware of their cultural heritage and generate a fresh perspective of knowledge systems that could legitimately be made part of their classroom knowledge and pedagogical skills. The study thus engaged students in a more practical pedagogical approach through a modified PAC designed argumentative discourse originally proposed and researched by an African scholar, Meshach Ogunniyi (2006). The modified PAC was underpinned by South African culturally-relevant experiences and contexts.

In addressing the kind of pedagogy that students in Africa should experience in science education, the following research questions are posed:

1) What are preservice students' statuses of science and indigenous knowledge prior to exposure to a Practical Argumentation Course?

2) What are preservice students' statuses of science and indigenous knowledge after engaging in a Practical Argumentation Course?

3) Why did the students change their minds, if they did, and how did they change their minds (in terms of CAT)?

4) How do preservice students respond to: How should IKS be included in science classrooms in re-envisioning education for African Higher Education?

Literature

The demise of racism in America in the 60s and apartheid in South Africa in the 90s has led to the transformation of the social justice agenda worldwide and this agenda includes the development of Indigenous Knowledge Systems (IKS) as a means to interrogate past colonial practices and philosophies. It has renewed efforts to re-install the confidence and knowledge base of Africans and other indigenous communities globally. This agenda has also led to educational institutions worldwide re-envisioning and transforming their curricula to meet their students' cultural needs. In this regard, the Department of Science and Technology-DST (DST 2004) has taken a lead to develop IKS and protect IKS intellectual property (DoTE 2004). DST (2004) describes IKS as:

> The Indigenous Knowledge Systems (IKS) developed and maintained by South Africa's indigenous peoples pervades the lives and the belief systems of a large proportion of the country's population. Such indigenous knowledge manifests itself in areas ranging from cultural and religious ceremonies to agricultural practices and health interventions. Indigenous knowledge (IK) is generally used synonymously with traditional and local knowledge to differentiate the knowledge developed by and within distinctive indigenous communities from the international knowledge system generated through universities, government research centres and private industry, … . (p. 10)

IKS is a theory of reality representing the way reality is experienced, interpreted and perceived by indigenous communities (Shumba 1995). Africans in Africa still practice their traditional culture consisting of art forms such as dance, rituals, healing and worship, and still employ survival strategies of traditional technology, medicine and health. They are also exposed to westernized cultures and science. Consequently, they hold aspects of both an indigenous and a scientific worldview, and are influenced by colonial practices and philosophies. A typical indigenous world-view is the notion that certain local plants have significant roles to play in people's healing. For example, the plant Ginger Bush (*Iboza*) (SANBI n.d.) is still currently used to treat coughs and influenza, among others. Hence, their indigenous knowledge (IK) of plants is still valuable and even today, widely practiced in urban communities as the high costs of allopathic medicines make IK the basis for choices and survival strategies for the majority.

The loss of cultural heritages, languages and knowledge is of concern worldwide (Aikenhead & Ogawa 2007; Diamond 2012) and there is a need to preserve, protect, educate, research and promote African cultural heritage as a whole (Kurin 2004). Kwame Nkrumah, Ghana's first president and a Pan-Africanist, suggested that we create the space and time, and seek opportunities for a more inclusive education that embraces the linguistic, indigenous and cultural resources of the home and community in embracing the globalized world (Ajei 2007). Indigenous knowledge can offer a different perspective on human experience than that provided by western empirical science (Kincheloe & Steinberg 2008). Ajei (2007) argues that a successful framework, designed for Africa's development, needs to be founded on indigenous knowledge and values.

Indigenous knowledge is a valuable teaching resource for motivating young people in Africa to participate actively in the education process as well as to engage critically in science-IKS issues. Naidoo (2010) adds that for education to be of value and relevance, participation in learning and performance must go together. She explains that relevance in science encourages 'learners to participate in classroom processes more deeply, learning in their own ways and bringing together their ideas, interests and experiences' (p. 6). While Aikenhead and Ogawa (2007) make an appeal for acknowledging collective worldviews, while Fleer (1997) calls for the inclusion of multiple worldviews, Govender (2009) adds that a science curriculum that includes aspects of relevant indigenous knowledge that recognises students' preconceptions and worldviews, affords a platform for discussion of different ways of knowing and encourages critical thinking, can attract more students to science. Thus, a curriculum that offers a climate of questioning, argumentation, and questioning sources of knowledge will ensure that students do become active participants in creating and defending knowledge positions.

IKS and Science Debates

South African education institutions are located in multicultural communities and there are often competing accounts of natural phenomena. The question of which aspects of, for example, African traditional knowledge should be included in science education, such as traditional African knowledge of agriculture and environment, and insights into conflict-resolution, is debatable. A traditional healer's (*sangoma)* insight that one should only use a limited amount of bark from a given tree, or that one should harvest no more than one-tenth of a given natural resource, constitutes an insight that may not be shared by many, but it has universal value and application. The phenomenon of lightning, as another example, is viewed differently when rural communities are exposed to its destructive effects, whereas in science classes, it is understood in terms of electrostatics. There are also competing claims from science educators (Cobern & Loving 2001) and indigenous scholars (Aikenhead & Ogawa 2007; Snively & Corsiglia 2001) about the status of IKS. Cobern and Loving (2001) argue that good science explanations will always be universal even if indigenous knowledge is incorporated into scientific knowledge. They argue that indigenous knowledge is 'better off as a different kind of knowlege that can be valued for its own merits, play a vital role in science education, and maintain a position of independence from which it can critique the practices of science and the Standard Account' (Cobern & Loving 2001: 51).

Arguments about whether IKS and science should be separate or integrated in the curriculum remain largely in the domain of researchers (Green 2008; Higgs 2008; Naidoo 2010) and preservice science students rarely get opportunities to debate this issue (Duschl & Osborne 2002; Sampson & Blanchard 2006). le Grange (2008) cautions us that 'The challenges for enacting an indigenous science curriculum are complex and there are no easy answers' (p. 824). Research papers by Ogunniyi (2004; 2007a; 2007b) indicate that enhancing IKS in classrooms is a long term curriculum goal as he and his post-graduate students have begun several small-scale studies with science teachers integrating IKS in their science classes. Studies have pointed out that when new concepts and innovative teaching strategies are introduced during new curriculum implementation, teachers are hugely challenged to adapt and they lack confidence unless a well-planned and supportive programme is in place (Erduran, Simon &

Osborne 2004; Simon & Richardson 2009). However, studies have also shown that when teachers are trained to incorporate multi-interactional instructional tools such as cooperative learning, discussion, argumentation, dialogue, and reflection, among others, their pedagogy skills are more effective in promoting new themes such as the Nature of Science (NOS), IKS and the relationships between NOS and IKS (Abd-El-Khalick 2005; Aikenhead 1997; Osborne, Erduran & Simon 2004).

Researchers (Bricker & Bell 2008; Erduran *et al.* 2004) argue that argumentation is increasingly viewed as a leading instructional approach and educational goal for science education. Students discussing and arguing in a group contribute to developing their argument skills further as opportunities to propose claims and defend via warrants are necessary to convince others in the group of the 'reasonableness' of the argument. Design research has shown how social norms of collaborative debate can be cultivated in science classrooms (Bell & Linn 2000) and as evidenced by PAC modules by Ogunniyi (2007a) where argumentation underpinnings were focused in controversial topics. The South African Curriculum and Assessment Policy Statements–CAPS (DoBE 2011), include 'critical thinking' as one of its goals, and it can be highly beneficial to both teachers and learners to learn how to identify and evaluate scientific arguments, as well as craft them. Consequentially, preservice students need to be trained in argumentation processes and develop skills to nurture argumentation in science classes.

Argumentation as a Tool for Teaching and Learning

Argumentation is a statement or constellation of statements advanced by an individual or a group to justify or refute a claim in order to attain the approval of an audience (Van Eemeren, Grootendorst & Henkemans 2002) or to reach consensus on controversial subject matter such as 'Is Indigenous Knowledge science?' Argumentation is critical to producing, evaluating, and therefore, advancing knowledge and it should be an essential aspect of science education and as a way to help students engage with the social construction of scientific and indigenous knowledge ideas. It is also valuable as a method of learning. Toulmin (1958) wants us to be wary of the universality of an argument in that it ignores human shortcomings and changing contexts. It is importance to take into account the context in which argumentation is occurring (Billig 1987). The issues of criticism and justification are central to argumentation. Perelman (1979) notes that both processes occur in social contexts and, therefore, are 'always 'situated'' (p. 117). Argumentation is understood only by examining both criticisms and justifications. In other words, 'one cannot properly understand an argument, if one fails to grasp what it is arguing against' (Perelman 1979: 121) and because both criticisms and justifications are situated, one has to understand the larger social milieu in which the argumentation is embedded.

Despite the importance of argumentation in scientific discourse, science educators have not, until recently, paid much attention to arguments advanced by teachers against curricular innovations such as science-IKS curricula (Ogunniyi 2007a). The limitation of space will not permit repeating several excellent reviews of studies that have employed explicitly reflective or argumentation-based approaches in the study of teachers' and preservice students' conceptual understanding of NOS, IKS, or both (Abd-El-Khalick & Akerson 2004; Hewson & Ogunniyi 2011; Ogunniyi 2007a; Simon & Richardson 2009). The findings emanating from these studies have not only highlighted the importance of arguments and dialogues in enhancing teachers', preservice students' and learners' conceptual understanding of the NOS and IKS, but also increased their awareness about the complementary nature of both systems of thought when presented in an inclusive instructional context. The issue now appears to be not one of abandonment and replacement, but one of addition, so that the earlier belief and the scientific belief co-exist. The learners' task is to learn the scientific and indigenous beliefs, and to become clear about when it is appropriate to apply one belief or the other. The issue of co-existence of the two thought-systems alluded to above should not be construed as confusion on the part of researchers or teachers to replace one thought system with another, but shows the reality in which teachers, preservice students and learners from indigenous communities find themselves (Ogunniyi 2007a). As Michie and Linkson (2005) have argued, a science-IKS curriculum that reflects valid images of both systems of thought provides indigenous and non-indigenous students access to different ways of knowing and interpreting experience. The prominence given to learner-centred activities such as dialogues, argumentations, discussions, and group activities in CAPS stand in sharp contrast to the use of a traditional instructional approach and rote learning associated with the previous apartheid curriculum. Also, these learner-centred activities have tended to increase teachers' and learners' confidence in undertaking various tasks called for by the new curriculum (Ogunniyi 2004).

Theoretical Framework

In this study, students were exposed to an argumentation framework based on a socio-cultural context based theory, the Contiguity Argumentation Theory (CAT) as proposed by Ogunniyi (2004). When two cultures or systems of thought meet, co-existence can only be found through conceptual appropriation, accommodation, integrative reconciliation, and adaptability (Ogunniyi 2004). Essentially, the CAT explains possible ways in which conflicts arising from clashing ideas or cosmologies such as science and IKS are resolved. Further, CAT assumes that ideas that come together will interact, overlap, or conflict with each other. One way of integrating such conceptions is by finding a larger, synergistic conception (Ogunniyi 1997). This leads to a higher form of awareness and a consequent deeper level of understanding than was previously possible. In other words, when ideas clash, an internal dialogue occurs to find some meaningful form of co-existence. CAT recognizes five categories into which ideas can move within a students' mind when discussing issues of different thought systems such as IKS and science. These are: *Dominant* - a powerful idea explains and predicts facts and events effectively; *Suppressed* - an idea becomes suppressed in the face of more valid evidence; *Assimilated* - a less powerful idea might be consumed into a more powerful one in terms of the persuasiveness of the dominant idea to a given context; *Emergent* - there may be circumstances where no prior knowledge exists and new knowledge has to be acquired or developed; and *Equipollent* - when two competing ideas have comparably equal intellectual force, the ideas tend to co-exist without necessarily resulting in a conflict. CAT is contextually-based and it can be applied to two or more thought-systems, unlike Toulmin's (TAP) theory, and provides a dialogical framework for resolving the incongruities that normally arise in these cases, for example science and IKS.

Methodology

This is a qualitative case study of why and how 85 preservice students' views of science and IKS changed after engaging in a Practical Argumentation

Course as an intervention strategy in a second-level Natural Science method module. Of the 85 students, 54 students have been schooled in western mode and come from mixed urban-multicultural areas, and hence are more familiar with the scientific worldview, while 31 have been schooled in a Western-African context and come from largely rural and indigenous backgrounds. Not all students were exposed to the school CAPS curriculum that demands new instructional approaches and goals in terms of contextualisation and indigenisation of school subjects. Hence, their exposure to IKS was minimal. All students were also exposed to two or three Natural Science content modules at the university. Students were asked questions about their perceptions of science and IKS at the beginning and end of the PAC course using questionnaires and during random individual interviews conducted.

While the module was of five months duration, the PAC course was implemented for three months as other aspects of the module had to be taught. The modified PAC course (different approach from Ogunniyi's 2007 which was more philosophical and historical) included a discussion of Nature of Science (NOS) using Views of Nature of Science (VNOS) (Lederman, Schwartz, Abd-El-Khalick & Bell 2001) questionnaire as a key document for NOS discussion. This was followed by the introduction of two argumentation patterns, TAP (Erduran *et al.* 2004) and CAT (Ogunniyi 2007a) and students' discussions of an article on Science across Cultures that highlighted African contributions to science (Selin 1993). Here, a number of scientific and medical accomplishments of African and Native American cultures were discussed such as early agricultural schemes, metallurgy, mining and smelting of copper, hieroglyphic writing and use of papyrus, mathematical and astronomical knowledge necessary to build the pyramids, a calendar and numeration system, and a carefully defined medical system, among others (Selin 1993). This was followed by the identification and uses of local indigenous knowledge of plants where students did research on the internet and submitted an assignment based on local indigenous plants and their uses, for example, Aloe Ferox, and how it is currently used in the pharmaceutical industry.

Students also conducted interviews with elders in their communities on the identification and uses of indigenous medicinal plants to verify the data obtained from internet sources. African cultural astronomy was then discussed (Govender 2011). Students then prepared for a debate on whether IKS is to be raised to the same level of science. A class debate was held and the audience then raised questions for the group to answer. Erduran *et al.* (2004) have argued that interactive classroom arguments and dialogues have tended to encourage students to externalise their viewpoints on any subject matter, hence as part of their PAC, students in this study were free to ask and raise questions, argue, dispute and express their views. The students were encouraged to see argumentation not as a means to denigrate other people's opinions or beliefs, but as an expressed social, democratic, and intellectual activity aimed at justifying or refuting a claim or as a means for attaining acceptance by their peers. Creating trust and freedom of expression amongst diverse cultural and racial groups of students encouraged an atmosphere where ideas were raised and contradicted by evidence and by the arguments of others.

Three purposefully chosen focus group interviews were also conducted towards the end of the PAC course (the end of the 3rd month) to determine if, why and how students changed their minds, on the status of science–IKS relationship, and on how they perceived the inclusion of IKS in the science curriculum in envisioning science education in Africa.

The data was analysed as follows: Data for questions 1 and 2 was obtained from 85 pre- and post-questionnaires and pre- and post-interviews conducted with ten randomly selected individuals to gain a deeper understanding and to clarify students' views of science-IKS. A simple random sampling was chosen as it provided an equal probability of selection of students for interviews and so minimised bias in the sampling and it also avoided human (lecturer) bias in selecting a particular category of students, either in terms of race or test performance. Students are wary and do question the criteria for their selection. All 85 student numbers were placed in a container for random draws done transparently in a classroom setting. In addition, a random sample of students' assignment-projects was chosen by selecting the work of ten students from a batch for analysis. Random sampling of individuals or units as a probabilistic technique is highly representative of the student population and allows us to make generalisations from the sample to the population and provides a measure of external validity. Individual pre- and post- interviews were carried out with the intention to verify the status of students' claims. All interviews were audiotaped and transcribed. The data was qualitatively interpreted by sorting and classifying the data. The data was eventually categorised into common themes after multiple readings and agreement with a co-researcher assistant in confirming students' CAT status. We must admit that to distinguish between Suppressed and Assimilated statuses did create some uncertainty, as some students' answers in the questionnaire were difficult to analyse exactly, though interviews did help to clarify in some cases. This was a limitation of the study.

Data for questions 3 and 4 were obtained from three focus group interviews consisting of four to five individuals per group and conducted towards the end of the module. These focus groups were purposefully selected as data was required from students from rural, urban and semi-urban areas to obtain a variation of science-IKS experiences. Excerpts of focus group interviews are presented as evidence of the discussions. The students' assignments were analysed for how examples of IKS was incorporated and referenced. Students' permission was sought for the use of data and interviews conducted.

Data Analysis, Results and Discussion

The data is presented in terms of answers to the research questions posed in this study:

Research Question 1: What are preservice students' views of the status of science and indigenous knowledge prior to engaging in a Practical Argumentation Course (PAC)?

Analysis of the 85 pre-questionnaires for students' views and knowledge of science showed that most students hold adequate scientific knowledge and perceive that science is the dominant way of understanding and learning about the world. Students were asked to write about their perceptions and views about, What is science? Is IKS science or scientific? Can IKS be integrated with science? Is IKS just tradition or cultural knowledge or is there some science embedded in IKS practices? Students could easily define science, give examples of scientific achievements and state their processes. In Nature of Science (NOS) tasks, students discussed the scientific worldview that science is understandable and subject to change, scientific inquiry demands evidence, science explains and predicts phenomena, the scientific enterprise is a complex social activity, ethics in science is an important aspect, and that science cannot explain supernatural/spiritual things. After

applying CAT classification, the pre-questionnaires confirmed that the majority of students held a strongly positivistic view of science [Dominant] and the world, while some held views that science is not the only source of knowledge for people and that without formal knowledge, they still survived [Suppressed and Assimilated].
For example, students wrote:

> Science is finding out theories that we have about the world. It's about investigations, experiments and questions that we come up with. [Dominant]
>
> Science is about explaining things like lightning and how things work. [Dominant]
>
> People have survived many centuries ago in the wild and in jungles of Africa and Amazon. They did not do science but still lived okay. In fact there are some people still living like that today. I think they learnt useful ways to survive from experience and shared this with their children. [Assimilated]
>
> IKS is outdated and superstitious knowledge of healers like sangomas. [Suppressed]

In the pre-questionnaire, students also completed NOS tasks in identifying fifteen cognitive and process skills in selected content topics such as astronomy and photosynthesis. Students adequately identified the different process skills in the selected content. For example, for scientific processes, one can investigate, through experimentation, the relationship of mass to acceleration of a falling object to explore gravity; and investigate the role of the sun's energy on plant growth by carrying out a series of systematic experiments on plant growth. It was evident from the pre-questionnaire that students used the concepts and examples developed in their Natural Science content modules to reflect on their understanding of science as constituting processes such as conducting experiments and developing cognitive skills such as analysis and synthesis. It can be concluded that students had a good knowledge of science process skills and sufficient content and understanding of content examples for teaching Natural Sciences in Grades 7-9.

After sorting the CAT status from pre-questionnaires, 27 students reported they had no or little understanding of what is meant by IKS and thought that science was the only acceptable knowledge worldwide [Dominant] while 48 were of the view that science is universal knowledge and IKS is cultural knowledge and not scientific [Suppressed], and 10 students felt that IKS may include some aspects of science and technology [Assimilated].

A random sample of pre-interviews conducted to determine students' views of NOS and IKS confirmed the status assigned in the pre-questionnaires especially in the case of Suppressed and Assimilated categories. Students replied in their pre-interviews as follows:

> Indigenous knowledge … IKS? No… I don't know what that means … never heard of that before…IKS! [Suppressed]
>
> Indigenous knowledge is old and traditional knowledge; it's what witchdoctors and old people know. I don't believe in all those things, you know. [Suppressed]
>
> Indigenous knowledge…yes, there is knowledge of lightning but superstitious ideas, and when to plant seeds, mmm… what about knowledge of trees and wood to make huts and grass to make things…like mats and hats. [Assimilated]
> Science is experimental and factual and its knowledge is verified by the scientific process. [Dominant]
>
> Science is applied in medicines, take all the research and how this has helped us to get better. I trust the results of science. [Dominant]

All students regarded science as useful, valuable and esteemed knowledge verified by scientists, but students responded with limited views of IKS. One possible reason for students' limited knowledge of IKS is that students emerged from a school curriculum that did not include IKS explicitly, whereas science and its nature were taught explicitly in their science content curriculum at university. It seems that only a few students were interested in reading outside their science knowledge exposure at university or ask their parents about IKS.

Research Question 2: What are preservice students' views of the status of indigenous knowledge and science after engaging in argumentative discourse (PAC)?

Evidence from post-questionnaires showed that students revealed a more nuanced understanding of the Nature of Science (NOS), detailed knowledge of Natural Science teaching strategies and provided more, richer and relevant examples, together with their relevant applications of the relationship of science and NOS. Examples of scientific achievement that student cited in their post-questionnaires included examples and applications of scientific concepts of energy, electricity, and chemistry. They showed understanding that science is a process, it is a human activity and that consensus of knowledge is reached based on evidence and theories and that theory is based on argumentation, rationalisation and subject to change. Their views on IKS now referred explicitly to historical backgrounds, culture, religion and value systems and students could narrate specific local, African and international IKS examples.

The examples below from the *post-questionnaire* illustrate how students' views have progressed:

> Indigenous System teaches us about our history and backgrounds. IKS gives us the definition of one-self.

> Heritage can be passed from generation to generation through IKS. [Assimilated]

> We have adapted IKS knowledge from our forefathers to survive now. [Assimilated]

> IKS has formed the basis and acts as a stepping stone for modern science, IKS help scientists to understand the management of biodiversity. It also helps scientists to understand agriculture, for example, crop rotation, pest control, and soil management. [Equipollent]

> Science is not permanent knowledge but can change as new experiments and theories develop. [Emergent]

> Science is developed by scientists who are human beings and sometimes they do make mistakes, so science is not perfect knowledge. [Emergent]

Ten students were also interviewed to validate the data in their post-questionnaire. They reported as follows:

> Nosipho: I have gained much from the PAC course, now I know that some medicinal plants are used to make our tablets, take the Aloe plant… lots of things are now made from it and this knowledge must have been taken from the indigenous people. [Equipollent]

> Gloria: I learnt a lot about IKS from Africa and I think science is still needed and used daily but I am not sure that IKS medicines is safe to use unless we carry out some experiments. With IKS we can learn more about the seasons and agriculture and the weather. [Equipollent]

> Olivier: We, in the Afrikaner community also have some IKS experiences regarding agriculture and planting of crops using the phases of the Moon but nowadays we use scientific methods especially in the farms as our farmers are trained in Agricultural Sciences. I think we can value IKS but I need to find out more. [Assimilated]

The post-questionnaires were analysed and the CAT status that emerged after the PAC argumentation discourse with student numbers were: Science is verified and universal knowledge and IKS is not science (Suppressed - 14); IKS is local cultural knowledge that contains some science and technology (Assimilated - 45); IKS is the basis for scientific development (Emergent -

15); IKS progresses, when it is subjected to more rigorous research, towards scientific knowledge (Equipollent - 11).

Research question 3: Why did the preservice science students change their minds, if they did and how did they change their minds (in terms of CAT)?

In comparing the change in students' views as the result of the PAC intervention, CAT's five categories were assigned (see theory) to students' responses of the status of science and IKS in their pre-and post-questionnaires. Prior to the PAC implementation, students' status were largely Dominant and Suppressed where science was considered superior and institutionalised knowledge, and valued more than IKS. Twenty-seven students in pre-PAC had no previous or very little idea of IKS and were from westernized-Christian cultures and were not familiar with other cultures. Classroom interactions with students confirmed that they were largely ignorant of indigenous knowledge and traditional knowledge of other groups but did enjoy learning about IKS.

After the PAC course, the Dominant (27), Suppressed (48), Assimilated (10) status of science-IKS shifted to Suppressed (14), Assimilated (45), Emergent (15) and Equipollent (11). In addition, two new categories emerged after PAC course. Why did these students change their views?

The examples below from *post-interviews* conducted with purposefully selected focus-groups illustrate how students' views progressed and provide evidence of change of their ideas:

> They both focus on the importance of whom we are and the environment we live in'. 'We are able to learn our history and society in which we interact with'. [Equipollent]

> Science has uplifted the world, made life convenient, safer and healthier-there would be no hospitals, healthy food and medicine. IKS provided the background knowledge for improvement and new inventions, scientists would be lost without it. An example of 'hoodia' plant used by the Khoisan has been developed by the

> pharmaceuticals. I feel the teaching and learning of science should promote the understanding of different cultural contexts in which IKS has developed. [Equipollent]

We see elements of IKS incorporated into science, for example, modern medicines use natural herbs as core ingredients. IKS can be tested through scientific method and at the same time science can form facts and explain IKS. For example, microbiology can explain how plants are used in IKS on a cellular level and how they affect us in the way they do. [Equipollent]

An analysis of assignment-project tasks revealed that students examined the uses of indigenous medicinal plants used in South Africa, from information obtained from books and the internet, including the plant's uses, history, chemical and side-effects. They also inquired and verified from their elders in their communities about the use of local plants. For example, medicinal plants such as Black Jack are used to treat wounds in circumcision and Helichrysum (*impepho*) as incense in rituals, Basil (*tulsi*) in Indian IKS is chewed to treat coughs and to remove toxins from the body. The African Ginger plant (*Iboza*) is used to treat the symptoms of influenza. This plant was obtained from the campus grounds and brought into the classroom by a student familiar with its uses. These examples supported interesting discussions and debates based on how IKS holders and scientists experimented and applied knowledge gained from exploring the environment.

All five CAT categories exist in a dynamic state of flux and transitional (Ogunniyi 2007a). I use 'transitional' as it quite complex to know for sure whether students really made significant changes in their viewpoints on a permanent basis or was it just for the duration of the module while their contextual experiences were still fresh. For example, students who were of Dominant status prior to the PAC intervention could revert later to this state in a different contextual situation. Some of their transitional changes may be attributed due to the PAC course where they acquired knowledge of IKS, their project experiences with their community and peers, from questions, argumentation and debates in class, their writing assignments and possibly reflecting from a few research papers on science and IKS. It seemed that a combination of the debates, lecturers' background knowledge of IKS and science, setting a classroom ambiance for discourse, and course materials may have had a strong impact on students' changes of their status of science-IKS. In the case of debates, students engaged actively in constructing and creating their ideas about IKS and the trusting environment in the class encouraged questions without censure. It is very interesting to note that students raised questions and held perspectives during the PAC course that are also the current debates raging between philosophers, scientists, science educators and indigenous scholars. Ogunniyi (2007a) in a similar PAC study conducted with four in-service teachers also provided evidence of teachers' change of science-IKS views from science dominant and infallible and IKS as outmoded to where teachers narrated that they now value and perceive IKS in a positive mode, especially in view of the tribal communities from which they come and they motivated that they had shifted to a critical mode in analysing both systems of knowledge and seeing the status of science-IKS in the broader socio-cultural-constructivist milieu.

Research question 4: Should IKS be included in science classrooms?

Students' views of the inclusion of IKS in science classes that emerged after the argumentation PAC module are: A little of IKS should be included and that IKS and science must be taught separately; IKS should be partially integrated with science with examples; IKS as cultural knowledge must be holistically integrated and included in science as it is a curriculum requirement for a learner-centred-approach. These views concur with a recent case study (Naidoo 2010) with practising teachers where the study found that the three teachers used three very different approaches through which IKS was brought in the science curriculum: 'an incorporationist approach, that brings IKS into science by seeking how**—***best IKS fits into science*; a separatist approach that holds IKS **—***side-by-side* with scientific knowledge; and an integrationist approach that **—***links* and makes**—***connections* between IKS and science. The approaches developed by the teachers were found to be informed by their biographies, values, cultural backgrounds and worldviews' (p. vi).

The derived categories above are supported by student interviews.

Separating IKS and Science

I see IKS as including morals and spirituality; it is more cultural and intuitive rather than rational. Hence I will separate science and IKS in the class.

I will compare similarities and differences or use argumentation in class to get learners to see how each one stands up for itself and against one another.

I will teach IKS and science on their own', 'First, I will emphasize the survival of the forefathers', 'I will compare early African achievements using the article on Egyptians and use argumentation and then teach science.

Partial Integration with Examples

I will teach science as a systematic way of understanding and integrate natural phenomena like lightning. I will discuss agriculture, fishing, and food reproduction in science and IKS with examples. Sometimes I will link them.

Full Integration of IKS with Science

I will use IKS to teach conservation, to value the heritage, and science also has ethics of honesty and openness.

Both are useful strategies. It will enable other learners to get information, share and debate ideas, carry their own investigations, and learn from others cultures. Learners will think 'out of the box' and be more creative and understanding rather than be bias.

Reflections

The above data and analysis of the four research questions provide evidence of most students' willingness to engage in IKS and encompass it as an alternative and culturally relevant way of knowing and acting in their classrooms. Students have acquired skills in argumentation and in the process acquired pedagogic skills to be implemented when they become teachers. They are cognisant of the macro-policies of IKS and how these can be implemented at a micro-level in classrooms. They are now familiar with policies of IKS with a view of re-visioning and Africanising the education curriculum that can be found in the South Africa National Curriculum Statement, the Revised National Curriculum Statement, and the Indigenous Knowledge Systems Policies. In addition, they are familiar with the relationship of African culture to education implementation. In this regard, the White Paper on Arts, Culture and Heritage view education as part of culture and acknowledges that culture itself is transmitted through education (DoAC 2013). Students are also aware that IKS creates a sense of wholeness and relatedness to human society and its survival. They have presented examples and situations where IKS is holistic. They have begun to perceive that IKS espouses a transcendental view of human experiences linked inextricably with the cosmos. They see some aspects of science emanating from IKS. In summary, most students now recognize IKS in terms of its plurality, diversity, and the holism of human experiences (Odora Hoppers 2002). Ogunniyi's (2007b) study confirms that teachers recognise the value of IKS to their sense of cultural identity and hence they support integration of IKS in the curriculum but they (preservice and inservice teachers) will need mentorship and training if it is to be successfully implemented.

There is now a growing body of research and policy that highlights the importance of incorporating indigenous knowledge into the curricula in Higher Education (Govender 2012; Green 2007; Ogunniyi 2004). The rationale is that it offers an additional way of processing information, making sense of the world in engaging in critical pedagogy and humanises the educative process rather than just accumulate information. The evidence from this study has shown that a curriculum that encourages discussion, argumentation, dialogue, and reflection is thus effective in promoting understanding of the relationship of science and IKS. Students in this study, while holding 'transitional and dynamic' views of science-IKS, see the value of introducing IKS with science after their exposure to the PAC design and some have acquired or are in a state of reaching equipollent status. The Practical Argumentation Course underpinned by Contiguity Argumentation Theory (CAT) provided a valuable instructional strategy and an epistemology for developing a pedagogy of humanistic education and yet promoted critical views of science and IKS. The majority of students indicated that both systems of thought are relevant in education and that IKS should be pursued further, as IKS research along scientific lines can also be the impetus for 'shaping scientific attitudes and values' (Loubser 2005: 86) amongst the citizens.

Conclusion

The study explored how preservice students' science-IKS CAT status changed when a Practical Argumentation Course (PAC), as an intervention strategy, was introduced to stimulate a dialogical discourse. At the beginning of the module, prior to intervention, students were confident in their content knowledge of Natural Science and in the Nature of Science but lacked understanding of IKS; most students held dominant and suppressed views and a few assimilated views of science and IKS. Students also held vague ideas of science and technology contributions from Africa. After the PAC intervention, students' status of science-IKS changed to: a decrease in the suppressed status, more shifted towards assimilated status and a few were identified as attaining emergent and equipollent status. The modified PAC course design that included resource materials, argumentation patterns, debates, critical questions, internet research, community research and active involvement by students in a constructive classroom environment all contributed to students' change in status.

Although the intervention PAC strategy was successful to an extent, to attempt to get more students to reach equipollent CAT status is a complex task and will require a refined engagement with more researched materials on IKS, and more time to engage in critical discourses via argumentation.

Implications

The study provides cautionary evidence that curricula in Higher Education can be transformed in re-visioning African education to take into account African epistemologies including IKS. The study confirms that it is possible for students to be engaged actively in critical debates via argumentation in tertiary education, but resources and time will be needed. It suggests that current research on IKS, textbook and people resources, artefacts and materials on IKS should be made easily accessible via an IKS databank to support IKS teaching. This access to data will make the incorporation of IKS easier for developing teaching and learning programmes in HE.

This study implies that transformative curricula at universities can be a platform for re-envisioning African education to meet the aspirations of African students. This goal can be achieved by the introduction of instructional strategies like argumentation discourses through similar PAC design, preferably designed collaboratively with Higher Education policies in mind and with involvement of stakeholder institutions like government, universities and communities.

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