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Effect of an Argumentation-Based Course on Teachers' Disposition towards a Science-Indigenous Knowledge Curriculum

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With the increased global awareness of the negative impact of scientific, technological and industrial activities on the environment and copious examples of sustainable practices existing in many an indigenous community, the new South African science curriculum statement has called on science teachers to integrate school science with the Indigenous Knowledge Systems (IKS). In response to this call, this study used an Argumentation-Based course (A-B course) to enhance teachers' understanding of the Nature of Science (NOS) and IKS and their ability to integrate science and IKS in their classrooms. Nine teachers participated in the course over a six-month period. Using questionnaires and interviews, the teachers' conceptions of, and awareness about the NOS and IKS were assessed before and after the course. Altogether, five of the teachers were interviewed and three of them completed a delayed questionnaire nearly two years after the course. After participating in the course, the teachers were: 1) more willing to accept IKS as a potentially legitimate aspect of a science curriculum; 2) more able to distinguish between science and IKS; and 3) more aware of the appropriate context to use the scientific or IKS worldview than was the case before the course. Although the teachers were enthusiastic about the value of the course as part of their training at the tertiary level, they were less optimistic about its success at the primary or secondary school level.

Key Words: argumentation-based course, indigenous knowledge systems, nature of science, science teachers

Background

According to Curriculum 2005 (C2005) policy statement:

> People tend to use different ways of thinking for different situations, and even scientists in their private lives may have religious frameworks or other ways of giving values to life and making choices… (Department of Education, 2002, p.12).

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Two main reasons given in C2005 for the call to integrate science with IKS are firstly that such systems reflect the wisdom and values that people living in Southern Africa have acquired over the centuries. Secondly, much of this valuable wisdom is believed to have been lost in the last 300 years of colonization. Indeed, many of contemporary South African teachers, especially the Whites and westernized Coloured and Black teachers, are unfamiliar with African IKS and with strategies to include IKS within the conventional science classroom.

In their rebuttal of the stance taken by Cobern & Loving (2001) that IKS be excluded from school science, Corsiglia and Snively (2001) argue that IKS offers knowledge that western science has not yet learned to produce. They contend further that the current environmental crisis has largely been caused by western scientific, technological and industrial activities. Several scholars have expressed a similar viewpoint namely that in the last three centuries, western colonial powers have not only used science (and technology) as a repressive instrument of social control in non-western societies, their activities have resulted in a harrowing legacy of epistemological silencing of other ways of interpreting experience, exclusivity, preemption of any possibility for coexistence, fruitful exchange of methods or dialogue around heuristic methods (Odora-Hoppers, 2002). Consequently, science (and technology) with its absolute power and self justification at the exclusion of other ways of knowing has also resulted in countless failed development initiatives around the world of which the most obvious perhaps is the current environment crisis threatening the very existence of the entire human race. It is this awareness perhaps that has forced certain scientists to pay increased attention to how IKS can been used for environmental sustainability in non-western societies (Hewson, 1988; Hewson & Hewson, 1988; Odora-Hoppers, 2002; Ogunniyi, 1988, 2004). It is against this background that C2005 has called for the re-discovery and the application of IKS to improve the quality of life of all South Africans.

C2005 has caused much controversy amongst stakeholders, especially the teachers probably because of the top-down approach in which the curriculum was implemented. For example, teachers who were expected to implement a curriculum (requiring a radically different instructional approach from the existing fact-oriented curriculum) were neither adequately informed why the existing curriculum was to be replaced nor equipped with necessary instructional skills for its implementation (Jansen & Christie, 1999; Ogunniyi, 1997). Besides, C2005 policy statement has failed to show how teachers can help their students to recognize and value IKS in order to integrate it with school science. It seems that the designers of C2005 were unaware of the complexity of such an inclusive curriculum or the difficulties that have been encountered in attempts to bring about conceptual change among teachers and learners worldwide (e.g., Aikenhead, 1996; Aikenhead & Jegede, 1999; Garroutte, 1999; Gunstone & White, 2000; Hewson & Hewson, 1988; Jegede, 1995; Manzini, 2000; Nichol & Robinson, 2000; Ogawa, 1986, 1995; Ogunniyi, 1988, 2004, 2005).

Attempts to improve teachers' understanding of the nature of science or the nature of IKS without helping them to translate this knowledge into classroom practice have been found to be inadequate (Nichol & Robinson, 2000; Ogunniyi, 2004). Several studies have further shown that the most effective way to get teachers to understand the NOS (e.g. Abd-El-Khalick, 2005; Aikenhead, 1996; Erduran, et al, 2004; Niaz, et al, 2002; Osborne et al, 2004; Simon et al, 2006; Zeidler, et al., 2002; Zohar & Nemet, 2002), the Nature of IKS or to integrate the two (e.g. Aikenhead, 1996; Aikenhead & Jegede, 1999; Garroutte, 1999; Hewson & Hewson, 1988, 2003; Jegede, 1995; Manzini, 2000; Nichol & Robinson, 2000; Ogawa, 1986, 1995; Ogunniyi, 2004, 2006) is to engage them in long-term mentoring, dialogues and explicitly reflective instructional approaches (e.g. Abd-El-Khalick, 2005; Barad, 2000; Ogunniyi, 2006, 2007a, b). Unlike earlier studies whose main focus was conceptual change in favour of science, we considered both science and IKS on an equal basis and as authentic ways of knowing or interpreting experience to meet the requirements a fair argumentation (Skirbekk & Gilje, 2001). We also thought it necessary to first assess the teachers' understandings, perceptions, attitudes, beliefs, presuppositions and practical arguments about science and IKS before exposing them to the course (Ogunniyi, 2004; 2007a).

Argumentation as An Instructional Tool

Within the last decade there has been an increased interest in determining the effectiveness or otherwise of argumentation in enhancing teachers' and students' understanding of the NOS (e.g., Driver et al, 2000; Ebenezer, 1996; Erduran et al, 2004; Jimenez-Aleixandre et al, 2000; Kelly & Bazeman, 2003; Kelly & Takao, 2002; Niaz et al, 2002; Osborne et al, 2004; Ogunniyi, 2004, 2006, 2007 a & b; Simon et al, 2006; Zohar & Nemet, 2002). Many of these studies have shown the importance of argumentation and dialogue as useful tools for enhancing teachers' and students' conceptual understanding as well as increasing their awareness of the tentative and material-discursive nature of scientific practices (Barad, 2000).

Toulmin's Argumentation Pattern (TAP) has been one of the most frequently used argumentation models by science educators to enhance teachers' and learners' understanding of the NOS (e.g. Driver et al, 2000; Ebenezer, 1996; Erduran et al, 2004; Jimenez-Aleixandre et al, 2000; Kelly & Bazeman, 2003; Kelly & Takao, 2002; Osborne et al, 2004). However, the TAP is more applicable to a deductive-inductive classroom discourse than what is required when IKS is to be integrated with school science. The Contiguity Argumentation Theory (CAT) on the other hand deals with both logical or scientifically valid arguments as well as non-logical metaphysical discourses embraced by IKS. The TAP essentially involves the processing of data, warrants, support, and claims (Toulmin, 1985). It has been applied as a methodological tool for the analysis of a wide range of science curricula and also as a heuristic for the assessment of student work and of both large and small group student discussions (Erduran et al, 2004). According to Lawson (2004) effective instruction encourages an atmosphere where ideas may be raised and then contradicted by evidence and by the arguments of others. Since the TAP is well known in the field of science education the rest of the background of this paper is devoted to the CAT.

Contiguity Argumentation Theory (CAT)

CAT, rooted in the Contiguity Theory, is a learning theory traceable to the Platonic and Aristotelian era. The Aristotelian Contiguity Theory asserted that one or two states of mind (or, as applied in CAT, two distinct co-existing thought systems such as science and IKS), tend to readily couple with, or recall each other to create an optimum cognitive state. This type of association has sometimes been considered the basic type to which all others are reducible. Philosophers have long recognized the phenomenon of association of ideas. For instance, Plato cites examples of association by contiguity and similarity. Also, Aristotle in his treatment of memory enumerated similarity, contrast, and contiguity as relations which mediate recollection. Hobbes was well aware of the psychological import of the phenomenon of association and anticipated Locke's distinction between chance and controlled association. However, it was Locke who introduced the phrase "association of ideas" and gave impetus to modern association psychology. Following Locke's notion of association of ideas, various scholars (e.g., Berkeley and Hume) were especially concerned with the relations mediating association. Berkeley enumerated similarity, causality and co-existence or contiguity as critical to recall or learning in general. Hume talked about resemblance and contiguity in time or place and cause or effect. Associationism is therefore a theory of the structure and organization of the mind. which asserts that every mental state is resolvable into simple, discrete components. In addition, mental life is explicable by the combination and recombination of these elemental states in conformity with the laws of association of ideas (Runes, 1975). Although CAT is largely underpinned by the Aristotelian Contiguity Theory, it regards such elemental ideas not as “concrete referents” but as dynamic organizing conditionals or “frames of reference” that galvanize the process of association or learning in general depending on the context in question. CAT holds that claims and counter-claims on any subject matter within (or across) fields (e.g., science and IKS) can only be justified if neither thought system is dominant. There must also be valid grounds for juxtaposing the two distinctive worldviews within a given dialogical space. The role of such a dialogical space is to facilitate the process of re-articulation, appropriation, and/or negotiation of meanings of the different worldviews. Students must therefore be able to negotiate the meanings across the two distinct thought systems in order to integrate them.

CAT recognizes five categories that describe the way conceptions can move within a student’s mind. These categories can also describe the movement of conceptions amongst students involved in dialogues warranting the mobilization of scientific and/or IKS-based conceptions. Concepts in the five categories exist in a dynamic state of flux in a person’s mind. The five cognitive categories are: dominant conceptions, suppressed conceptions, assimilated conceptions, emergent conceptions, and equipollent conceptions. A conception becomes dominant when it is the most adaptable to a given context. However, in another context the same dominant conception can become suppressed by, or assimilated into another more adaptable metal state. An emergent conception arises when an individual has no previous knowledge of a given phenomenon as would be the case with many scientific concepts and theories e.g., atoms, gene, entropy, theory of relativity etc. An equipollent conception occurs when two competing ideas or worldviews exert comparably equal intellectual force on an individual. In that case, the ideas or worldviews tend to co-exist in his/her mind without necessarily resulting in a conflict e.g., creation theory and evolution theory. The context of a given discourse plays an important role in the amount or intensity of emotional arousal experienced by the participants in such a discourse. More details about these five cognitive categories have been reported elsewhere (Ogunniyi, 2007a,b) and will not be repeated here.

Purpose of the Study

Since its inception in 1997, the new South African science curriculum encouraging the integration of science and IKS has not been favorably received by teachers (e.g., Jansen & Christie, 1997; Ogunniyi, 1997, 2000, 2004, 2006). Rather, it has been a subject of heated debate among stakeholders. The purpose of the study therefore, was to determine the effects of an argumentation-based course (including dialogues and discursions) on teachers’ ability to: express their views freely; develop a better appreciation for the new curriculum; and to select appropriate instructional methods to integrate IKS into the science classrooms.

Method

Argumentation-Based Course (A-B course)

The Argumentation-Based course (A-B course) was underpinned largely by the CAT described above. The course integrated studies in the history, philosophy and sociology of science and to some extent anthropology, linguistics and African IKS. The purpose was to link science with IKS. Briefly, the history of science component of the A-B course involved lectures and reading assignments on the pre-Socratic scholars' notions about the universe; Greek science and the controversies surrounding the nature of matter; medieval science of motion (including significant contributions made by western and non-western scholars) especially the arguments about the moving earth; Ptolemaic geo-centric system versus the Copernican heliocentric system; the change from Aristotelian to Newtonian mechanics; Newton's arguments about his so-called Systems of the World; Descartes' mechanical system of the world; alchemy versus modern chemistry; Einstein's versus Bohr's arguments about nature of reality; etc. The philosophy of science component of the A-B course was based on the works of numerous philosophers of science. The topics included: forms of reasoning in science and associated ontological, epistemological and axiological issues; the roles of empiricism, rationalism in scientific inquiries; the roles of laws and theories in scientific explanations; causality, probability and determinism; mechanistic explanation versus teleological or anthropomorphic explanations; the Nature of Science, etc.

The sociology of science component examined contemporary socio-scientific issues and science education, for example, the etiology of HIV/AIDS; the roles or purposes of humans in the universe; the roles of science and technology in environmental conservation; causes and/or consequences of global warming; the ethics of population control; fraud in scientific reporting; commonly encountered dissenting positions within the scientific community, etc. The IKS component was based on the works of sociologists, anthropologists, linguists, scientists and science educators. Among others, we examined the holistic nature of IKS and cultural beliefs, and explored a number of studies on IKS in non-western societies. More details of the content and processes in the course have been published elsewhere (Ogunniyi, 2007a,b).

Teachers' Profiles

Although the nine teachers (designated as T1-T9) enrolled in the A-B course differ in age and teaching experience, they share certain common characteristics such as: coming from the so-called Coloured and Black communities; teaching science and mathematics in the previously disadvantaged schools; having been schooled in the mechanized worldview of western science and sharing strong religious beliefs. Also, with the exception of T8 and T9 all the other teachers are males.

T1 is a 40 year-old biology teacher from a neighbouring southern African country. He is a very zealous Seventh Day Adventist, speaks his native language as well as German, Afrikaans and English. He expresses his viewpoint strongly and tends to be repetitive. T2, an active participant in class discussions, is a 42 year old Afrikaans speaking science-mathematics teacher. He is an Anglican and like T1 expresses his religious views without apology. T3, a generally shy and quiet person, is a 36 year-old Xhosa speaking physical science teacher and a liberal Methodist. He seems to come alive only when asked to express his viewpoint. T4 is a 50 year-old Afrikaans-English speaking physical science-mathematics teacher. He is a zealous Moslem and by far the most articulate and argumentative member of the group. T5, a 43 year-old and an Afrikaans/English speaking biology teacher is a zealous Anglican and perhaps the most politically active person in the group. T6 is a 51 year-old Afrikaans speaking mathematics-science teacher of the Dutch Reformed Church. T7 is an Afrikaans speaking middle school science, mathematics and technology teacher. He is soft spoken but a staunch Anglican. T8 is a 39 year-old primary mathematics-science teacher with a liberal Dutch Reformed background. T9 is a 51 year-old science teacher (with an Engineering background) from South-East Asia. She is the wife of a Methodist missionary, has lived in South Africa for 18 years, and has a strong religious viewpoint. While we were well aware that the teachers' profiles are likely to influence their views about the NOS and IKS, their dispositions towards C2005 and the outcomes of their exposure to the A-B course we also assumed that the course would provide them the needed opportunity for dialogue and to externalize their thoughts about the new curriculum--a matter that seems to have been overlooked by the designers of that curriculum.

Implementation of the Argumentation-Based Course

Each session of the A-B course systematically used elements of the CAT described above. The first one and a half hours of each three-hour class session of the A-B course was an interactive lecture on a topic employing CAT and, to some extent, the TAP. The former was found handy for interrogating the teachers' conceptions of both the NOS and IKS while the latter was used largely to explore their views about the NOS. This was followed by one hour of arguments and discussions based on questions raised by the teachers as well as trigger questions. The teachers were encouraged to raise or answer any questions, argue and express their views or refute any claims made by the lecturer or their fellow students without feeling intimidated. They were encouraged to base their arguments on sound reasoning while at the same time being sensitive to the religious beliefs and sentiments of their counterparts. They were also encouraged to see argumentation not as a means to denigrate other people's opinions or beliefs, but as a social, democratic and intellectual activity aimed at justifying or refuting claims made by the texts, course instructor and by fellow teachers. A course notebook contained numerous articles and chapters, and course participants were required to complete course assignments including the submission of two reflective essays. The last 30 minutes was used to check in with the teachers. clarify issues and ideas raised during the discussion, seek for consensus and conclusion, and plan for the following week.

The NOS and IKS (NOS-IKS) Questionnaire

During and after the course, the nine teachers completed the Nature of Science and Indigenour Knowledge Systems (NOS-IKS) questionnaire in which they were asked to identify whether given statements represented scientific or IKS viewpoints, or belonged to the "I Don't Know" category. The teachers were also invited to select and rank the 10 top teaching strategies out of a total of 16 in terms of usefulness for integrating IKS with science.

The development of the NOS-IKS questionnaire was grounded in practicing teachers' views. First, over 50 items deemed relevant to the nature of science and IKS were generated and administered to 45 experienced science teachers. Through a sequence of refinements based on scholarly critique and pilot tests, the final questionnaire had 50 items regrouped into five major sections: 1) respondents' identification with statements concerning the C2005 requirement that the curriculum should be sensitive to learners' IKS; 2) respondents' categorization of 21 statements as either science, or IKS, or both; 3) respondents' rankings of instructional methods most appropriate for integrating IKS with the science curriculum; 4) respondents' views about integrating science and IKS; and 5) demographic information. Validity checks involved average pair-wise ratings of items from 1 to 5 (1 being a poor item and 5, an excellent item) by four science educators on the final draft of the NOS-IKS questionnaire. Using the Spearman Rank Difference formula, we obtained 0.98. An odd-even and a split-half correlation was 0.92 and 0.99 respectively (Ogunniyi, 2006). These data show a strong face, content and construct validity of the instrument.

Five teachers (T1, T2 T3, T4 and T5) were interviewed and three (T1, T3, and T5) also completed a delayed post-test of the NOS-IKS questionnaire two years after the course.

Some of the original group of teachers left town for jobs in other parts of the country and were unavailable for the follow-up interview. The teachers interviewed were shown their responses to the NOS-IKS questionnaire they had completed previously and were asked to explain their responses. These interviews were analysed qualitatively by identifying verbal statements (units) that characterized the essence of each teacher's ideas. Further, the teachers were required to write two reflective essays on any issue covered in the argumentation course. This provided us with additional insight into the nature of the teachers' perceptual shifts relative to the new curriculum. However, space limitation would not permit us to present much of the data derivable from these essays.

Results

We report our results in the context of our original questions, and combine the descriptive data with verbatim interview data. Where pre- and post-test changes were noted, we applied the CAT categories to describe the type of changes.

Table 1. Teachers' ratings of statements as representative of science and IKS.

Scientific Conceptions	**Pre-test %**	**Post-test %**
IIt is highly probable that the universe occurred by chance and undergoes continuous evolution	44	78
Time is real, continuous and irreversible	56	67
Space is real and has definite dimensions	22	67
All events have natural causes only	56	67
Language is an important tool that can be used to describe, explain, but not create natural phenomena	56	56
Nature is real, observable and testable	78	67
Sense perceptions are the only valid and reliable means to understand nature	67	44
Indigenous Knowledge Conceptions		
Humans are capable of understanding only part of nature	67	78
Events have both natural and unnatural causes	56	78
A supreme being created and controls the universe	67	67
Language is an important tool that can be used to explain, predict and even create natural phenomena	56	67
Time is real, continuous and cyclical	22	44
Matter is real and exists within time, space and the spiritual realm	44	56
Sensory perceptions are not the only means of understanding nature, i.e., certain experiences defy sense perceptions	67	44
Combination Science + IKS Conceptions		
Humans should harmonize with nature rather than exploit it	44	11
The universe is orderly, partly predictable and partly unpredictable	44	22
Nature is real, partly observable and partly unobservable	44	11
Space is real and has definite and indefinite dimensions	33	22

The biggest change in the pre- and post-test data was that after the Argumentation-Based course the teachers realized that the scientific method was less relevant or appropriate for investigating IKS than they previously thought. In addition, in the post-test, more teachers believed that it was realistic to integrate IKS with science in their classrooms. From the NOS-IKS questionnaire and interview data we extracted the following statements, which we categorize in terms of CAT. There was similarity between the pre- and post-test scores concerning the teachers' agreement with the C2005 mandate to integrate IKS with the science curriculum. The teachers indicated that as a result of the A-B course they made deliberate attempts to incorporate their students' cultural knowledge in classroom discussions and that their students in turn responded enthusiastically to such socio-scientific issues. Changes in teachers' classifications of the given statements as either scientific, indigenous or a combination of both are provided in Table 1.

After participating in the course, more teachers categorized the following statements as scientific: the reality of space and time; role of language in representing reality; the role of chance in explaining causality; and the nature of reality itself. Likewise, more teachers categorized the following conceptions as IKS: the role of the spiritual realm; the existence of unnatural (supernatural) causality; the limitations of human ability to understand nature; the role of language in creating reality; and the cyclical nature of time. Despite the need to be cautious in interpreting the results in Table 1, it seems that the teachers' religious or IKS-based worldview may have influenced the relatively low percentages associated with some of the items reflecting the scientific worldview at the pre-test stage e.g., the chance origin of the universe and its evolving nature, space being real and having definite dimensions. Conversely, their commitments to a religious or IKS-based worldview might also be responsible for the relatively high percentages associated with certain statements e.g., humans being capable of understanding only part of nature, a Supreme Being creating and controlling the universe, and certain experiences defying sense perceptions. At the post-test however, the teachers appeared to maintain essentially an equipollent stance. This stance is further corroborated by the interview data.

Before participating in the A-B course the conceptions of reality by most of the teachers' viewpoints were dominated by scientific ideas while their IKS-based conceptions were suppressed. In certain cases evidence of emergent or equipollent worldviews are discernible. However, after the A-B course some conceptual change was discernible. The excerpts below are representative of the shifts in the teachers' perceptions on various items of the NOS-IKS questionnaire:

Before the course

Science is dominant and IKS is suppressed:

> IKS ideas are uncivilized, backward and primitive... science is right and done by the "elite" group called scientists. Science is about meaning-making in real life situations. (T1)
>
> Science and IKS are two separate entities that cannot be combined. Science is concerned with proving things to be true i.e. the natural phenomena. Science is the only source of knowledge that can liberate the society and is clean in all respects...IKS is a commonsensical worldview that needs not be taken care of, simply because the existence of modern western science is enough. (T2)
>
> Science is infallible....I have very little idea about IKS. (T3)

> Science is a body of knowledge with useful methods that provide for verification, objectivity and experimentation. (T8)

After the course

Emergence of IKS conceptions:

> I don't need to go to Hollywood and see science. I can safely say that I value indigenous knowledge systems and I am proud to belong to this system, I want to learn more… I now see a lot of indigenous knowledge systems that make sense. I am hesitant to say what is civilized now and what is not. (T1)

> Faith can also be a part of IKS. (T2)

> Western science alone is playing a leading role in creating the so-called "lost generation" because as a learner I did not know my rights, or I was deprived the proper knowledge and that resulted in becoming more westernized. (T3)

> Many times scientific models/theories are controversial e.g., the heliocentric nature of universe, and later the controversial paradigm is replaced. What I learned (in the course) was not enough to formulate strong views about the subject (of IKS). (T4)

> IKS involves fields not recognized in science. (T5)

> Indigenous knowledge reflects the wisdom of people who have lived a long time ago. With IKS the emphasis seems to be on who said what, rather than on what was said. (T8)

Equipollence of IKS and science conceptions:

> I used to look at the two (science and IKS) and treat them as two separate entities that cannot be combined. Science is concerned with proving things to be true i.e. the natural phenomenon. Science is the only source of knowledge that can liberate the society and is clean in all respects…I did not place the ideas of IKS anywhere but only took it as a commonsensical worldview that needs not be taken care of, simply because the existence of modern western science was enough. Science is mainly known to be concerned with probabilistic truth i.e. the truth I believed in was not 100% correct but could change as the time goes on. Science is selfish, i.e., has no respect to culture, but that does not make it bad for society…I assigned value to IKS because I began to understand its necessity and how selfish science knowledge is undermining IKS, whereas I think it (science) was born by IKS. I had my perceptions changed about them (science and IKS) and could bridge the two in a science classroom. They are compatible with each other. (T3)

> IKS is traditional knowledge that people use to live in harmony with nature. Science is what scientists do, e.g., nuclear physics research. Superstition is based on neither science nor IKS…. Examples like acid rain, rain forests, etc., would definitely cross the boundaries of science and IKS. IKS is scientific, e.g., healing with plants. (T4)

> Before the course I used to think… IKS is a primitive science that has no place in this world. The course opened my eyes and managed to make me see the other side of life with a fine eye. I began to assign value to IKS and stopped isolating IKS from the

> sciences that I teach daily. Hence it is imperative for me to teach IKS whenever I teach. (T5)

An interview with T4 illustrates the sort of arguments, contentions and perceptual shifts encountered among the teachers, particularly T1, T2, T3 and T5. R stands for our Research Assistant:

R : How do you progress your learners with difficulties with the scientific knowing?

T4: I have been exposed to science and the way I was exposed was sort of the distorted view of what the scientific method is and what science is all about and the nature of science. That is like if it has got all the answers in science. For me teachers need to be exposed to what is the nature and philosophy in science so that they do not project a picture of science as …you know…this is the answer to all the problems. On the other hand, my knowledge of indigenous knowledge systems and many science teachers knowledge is very limited. It is because there is not enough information out there that teachers can tap into so it is true that learners come with those difficulties… If we really want to do justice to the integration of the two systems we need to retrain science teachers in both the science as well as the IKS.

R : Item 2.1 construes science as problem solving. Do you think this is applicable to IKS?

T4: As I said earlier I do not know a lot about indigenous knowledge systems. But I would imagine if you want to integrate two systems there must be some sort of structure, what the structure is I do not know. If I say it should be like "problem solving" I would imagine it would be a good start to have those elements, not necessarily in that order.

R : Explain why you classified item 2.1: "Space is real and has definite dimensions" as both science and IKS you classified this statement as both science and IKS.

T4: If you look at the huts built by the people in the rural areas of Africa is based on indigenous knowledge. The huts have definite dimensions and the huts look similar in a particular region. To me this is what IKS is all about …it is about a particular region…in that particular region the huts built over the years it looks the same. So they would have…in their sense (in their community)…definite dimensions.

R : Explain why you grouped "Regularity of events in nature depends on how the beings behave" as IKS

T4: For me it would be like a particular brand of IKS. If you look at African "juju"…it is the belief of those people that something would happen to someone.

You grouped item 3.3: "A Supreme Being created and controls the universe" as IKS

T4: Based on science, it is not scientific.

R : You grouped item 3.4: "Space is real and has definite and indefinite dimensions" as both science and IKS. Does science say space has indefinite dimensions?

T4: You tell me what are the dimensions of the atmosphere? The atmosphere is one of the areas science is dealing with and that space is not definite. There are no dimensions. It is like the universe extensive so far as what we can think. What science does is that to sort of indirectly …well that star is the furthest…every time they might get another star a little bit further because of the telescope that is invented.

R : Why did you group item 3.5: "Time is real and has a continuous, irreversible series of duration" as science and IKS? Does IKS say that time is irreversible?
T4: That is not, I think, IKS. I do not know if IKS say time is reversible but that is what I am thinking.

R : You grouped item 3.6: "Matter is real and exists within time, space and the spiritual realm" as IKS. Could you elaborate further why?
T4: Anything that has got to do with spirits… you will find that science is not including math…I am not saying that it is necessarily the right thing or not…that is why.

R : Explain why you grouped item 3.7: "Sensory perceptions are not the only for understanding nature i.e. certain experiences defy sense perceptions" as IKS. Are there other perceptions?
T4: To me, I wonder if one can generalize the IKS. It is not necessarily…If you look at traditional healing it is not necessarily all about the senses. It could be in some cases about the senses, but there are other cases that it is not about what we can observe, feel touch or hear.

R : Explain why item 3.11 asserting that: "Language is an important tool to explain, predict and even create natural events" as IKS
T4: The problem with this kind of questionnaire is it is almost like as if IKS is uniform. To me there are different IK systems and they might be at loggerheads with one another.

R : You grouped the statement: "Nature is real, partly observable and partly unobservable" as both science and IKS. Explain.
T4: There is a lot of subatomic science that is not observable but in science you still have theories like nuclear physics, nuclear chemistry is based on these theories and yet the people did not observe. Who observed an electron? Yet we talk about electrons as if… you know...we have morals to that…but nobody observed ...like with the senses...this are electrons. There is the effect.

R : Do you have IKS explanations for this?
T4: To me most of IK systems is not necessarily underpinned by observation. So for them that is not a criteria that it should be like that where as science, the way we present it is that observation should be there. But for example, in the field of science it is not direct observation, it is not about the senses but it is about the effects.

R : Item 3.14 asserts that "The universe is orderly, partly predictable and partly unpredictable" as both science and IKS. Explain.
T4: The models in science are they're to explain things and you will find that sometimes it predicts. In another case the predictions are not necessarily the case, for instance in nuclear physics you have a term called "magic numbers" and these numbers happen there but they cannot explain. So there are no predictions. There are others that could be predicted but for certain things it does not work out the way the model says it should be…that is why they refer to as "magic numbers".

R : Explain why you grouped item 3.17: "Humans are capable of understanding only part of nature" as IKS.

T4: To me science obviously believes that may be everything one day would be believed and understood by scientists. But that is not in the nature of things. There would be certain things until the end of time that science will not be able to explain. To me those are the things that in some IK systems would be like that. Now that we need those things to survive because we have been surviving without a lot of knowledge that came late…

R : You grouped item 3.18 asserting that "The regularity of things can be taken for granted as both science and IKS. Explain.

T4: Well, if you look at day and night, you will take it for granted. Seven hours from now it will be night whether you call it indigenous or science; you take it for granted that is a regular happening.

R : You gave no response to item 3.19 asserting that, "Time is real, continuous and cyclical" Why?

T4: I do not believe that time is cyclical.

R : Explain why you grouped item 3.21 stating that: "Humans should harmonize with nature rather than exploit nature" as IKS.

T4: In the scientific world, scientists do not believe necessarily that they should harmonize with nature. For instance, the case of Hiroshima and Nagasaki, pollutions, environment, etc it is about what the superpowers want to do. If you look at indigenous communities, that has been the basis for their survival.

R : With respect to item 3 (b): Do you think that the goal of integration of science and IKS is realistic? Explain why you stated yes.

T4: I mean if it was like…should it be there? My answer is "yes it should be there". Because what we want is, all rounded citizens.

Among others, the excerpt above suggests that as a result of the A-B course, the teachers became more argumentative and were willing to express their views more forcefully than before the course. In other words, the course seemed to have provided the opportunity and the dialogical space to express their viewpoints on issues relating to science and IKS. While the teachers improved their understanding of the NOS and IKS they also became aware of situations where science or IKS was the most appropriate worldview to adopt in dealing with such situations.

The teachers were asked to rank the top 10 (out of 16) instructional options suggested for integrating science and IKS. They gave the highest ranking (a rank of 1) to the constructivist instructional view to: "Start lessons with students' ideas before presenting the scientific view." In the second and third ranks were: "Use a holistic/ integrated instructional approach," and "Assess each knowledge claim with its own assumptions and standards rather than using science to judge IK as true or false." (e.g. see Garroutte, 1999; Nichol & Robinson, 2000). The instructional method designated "Frequent use of provocative, argumentative or inquiry-based questions" was ranked 8th in both the pre- and post-test out of the 16 instructional options listed in the NOS-IKS questionnaire. The relatively low ranking despite their favourable comments about this instructional strategy was a bit perplexing. However, when one realizes the context in which the teachers taught science, it should not be all that surprising.

As revealed in the NOS-IKS questionnaire and the interview, the teachers were of the view that: 1) they needed a long-time mentoring to master the new instructional approach; 2) they still had to fulfill the requirements of the old examination-bound science curriculum which had not yet been phased out at the time of the study; and 3) they had to deal with the challenge of their essentially traditional culture which promotes learning by rote or passive obedience to superiors rather than by argumentation.

Although the teachers showed increased willingness to teach IKS along school science, some of them were either speculative or did not provide sufficient hint at how they would do this. The excerpt below is representative:

> It (the A-B course) will greatly influence my teaching approach. I now know that learners are loaded with a lot of science from home and we need not ignore them… I now know where to start when teaching. I now know why certain things should be taught the way they are taught… I am going to be confident and accessible now. I will definitely be considerate of peoples' worldviews and know the contiguity of learning. (T1)
>
> The course will influence my instructional practice in the science/mathematics class…I will understand the way in which my learners see things in class that are different and respect them even more…Honestly speaking I am in the process of chewing the content, trying to make sense of certain new ideas and assimilating them to the existing experiences. But so far, I am very happy to have gone through the discourse. It opened my eyes as an educator. (T2)

The speculative responses above may be related to the way item 6 (d) of the NOS-IKS questionnaire is structured namely, "How has your understanding of the NOS and IKS affected (or will affect) your instructional practice?" However, item 5.2 that is more direct seems to have evinced clearer responses from the teachers. The question is, "How do you personally 'bridge' the two worlds of science and IKS in the science classroom?"

> Before the course
>
> I provide an atmosphere of collaboration and reinforce the need to work with other learners. Each collaborative activity allows individual learners to engage and share their knowledge and experiences and to gain new and different ideas by working with others. I encourage trial and error, and repeated attempt at activities in developing skills. (T1)
>
> I find out how much they know about a topic at hand encouraging them to bring their personal views about it and start to show how and where science is featuring in whatever is under discussion. (T3)
>
> First, educators need to be sensitive to IKS. They also need to learn about IKS before "bridging" can take place. (T5)
>
> After the course
>
> Collaborative activity; trial and error method; and negotiation and discussions (T1 at pre-test).
>
> Firstly I encourage my learners to master and critique scientific ways of knowing without sacrificing their own ways of knowing. One clear indication is that I develop instruction that makes border crossing explicit for my learners, facilitate this border crossing and teach the knowledge, skills and values of Western science and technology in the context of society roles (for example, social, political, economic and ethical roles) (T1 at delayed post-test).

> Unconsciously I was discussing with the learners in a science class explaining that science is not the only way we need to rely on. There are also important IKS that make us to survive and that also need to be integrated. (T3 at post test)
>
> I do not really attempt to bridge this gap (T5 at post-test). Although my personal knowledge of IKS is limited, I create an educational environment in which learners are proud of their IKS and feel comfortable to express their knowledge and opinions. (T5 at delayed post-test)

Lack of space would not permit reproducing similar comments made by other teachers to those above. Nevertheless, the comments above show the teachers' propensity towards a paradigmatic shift in their instructional practices most probably as a result of having been exposed to the course. Generally, the teachers had become more aware of the need to integrate science and IKS than was the case before the course. Some even attempted to facilitate collaborative work and discussions stressed in C2005. However, they were not explicit enough about the instructional methods they used to integrate science with IKS in their classrooms.

The teachers were asked if the A-B course should form part of their academic training programme. Here are some of their comments:

> I don't only think, but I am sure it (A-B course) is what we need… I think this module should be introduced to undergraduates as well because the majority of the teachers are not found at this (postgraduate) level of education. (T1)
>
> Yes I strongly think so, and also suggest that institutions should embark on getting science teachers adequately prepared, not only at masters level, but at the HDE (Higher Diploma in Education) level for example. (T2)
>
> Teachers (myself included) should have more exposure to the course in the form of videotapes and group discussions to give them the opportunity to practice this new integrated instructional model and to share their experiences and learn from one another. (T3)

In the delayed post-test of the NOS-IKS questionnaire after approximately two years, T1, T3 and T5 gave their overall impressions of the value of the course. The excerpts below were extracted from the lengthy comments made by both T1 and T5:

> Before enrolling the course, I did not know that social and cultural conditions affect the direction of science… I used to habour thoughts that where all else fails, science is held up as a distinctly civilized pursuit, and something that can justify whatever other problems it may entail. This supposition worked well against my general impression of primitive society as stupid, ignorant, or superstition-dominated... After enrolling (in the course), I now understand that civilization has no monopoly on knowledge… The (course) has made me understand how science works and allowed me to distinguish science from non-science… I now hold the view that science is based on the premise that our senses, and extensions of those senses through the use of instruments, can give us accurate information about the universe…Even with such constraints science does not exclude, and often benefits from, creativity and imagination (with a bit of logic thrown in)…. I do encourage my learners to learn IKS, and western science and technology in a way that empowers them to make every day choices. (T1)

> Before the course I was not too serious about IKS in science education. Also I did not know anything about IKS of most South African cultures except my own…. I tended to believe that the facts, laws and theories in modern science was the only form of knowledge valid in teaching science… and IKS was a system of knowledge that was useless. After the course (I realised) that there is science in all IKS and an integration of the two could improve learner achievement in science…This course and the understanding of constructivist education led me to realize that in a multi-cultural classroom IKS would make learning contextual for all…. I believe that it is the higher institutes' responsibility to expose future teachers to various aspects of the many different cultures…. It should be remembered that we (South Africans) were isolated from each other by law. This is a way to battle the remnants of apartheid and improve tolerance among the numerous cultures in our country. (T5)

In terms of the CAT, and as shown in Table 1, the excerpts above suggest an equipollence stance on the part of the teachers i.e. science and IKS are seen as complementary.

Discussion

Our data showed a change in the teachers' understanding about IKS and its connection with science, and the possibility of an integrated science-IKS school curriculum. Our selected verbatim quotes revealed changes that we categorized according to Contiguity Argumentation Theory (CAT). As indicated before, this is clearly different to the stance taken by teachers in earlier studies (e.g. Jansen & Christie, 1997; Ogunniyi, 2000, 2004, 2006). In the delayed post-test of the NOS-IKS questionnaire, T1 came to appreciate the tentative nature of science. He further suggested that science and IKS should be allowed to co-exist rather than use the former to replace or denigrate the latter. For him, IKS could enrich or complement students' understanding of natural phenomena from multiple perspectives so long as they know which perspective is appropriate for a given context. A similar sentiment was expressed by T5. Their views agree with earlier findings in the area (e.g., Aikenhead, 1996; Aikenhead & Jegede, 1999; Fakudze, 2004; Gunstone and White, 2000; Jegede, 1995; Ogunniyi, 2000, 2004, 2006). T3 suggested that being westernized through the agency of school science had resulted in what he called the "the lost generation." Students such as him have been assimilated into the western culture and consequently alienated from their own indigenous cultures. His observation is well supported in the literature (e.g., Aikenhead, 1996; Aikenhead & Jegede, 1999; Bishop, 1990; Garroutte, 1999; Hewson & Hewson, 1988; Jegede, 1995; Nichol & Robinson, 2000; Ogunniyi, 1988, 2000, 2004). Indeed, of the school subjects that were taught to pupils and students from colonized indigenous cultures, science was marketed as a culture-free subject. According to Bishop (1990), it is ironic that western science (an inappropriate term, since many cultures have contributed to it) has been presented not only as an accurate way of knowing, but also as the only valid interpretation of the universe. Bishop (1990) contends further that western science has been used as an instrument of oppression in the subjugation of indigenous peoples through the mediating agents of trade, education and administration. The excerpts from the delayed post-test NOS-IKS questionnaire with T1 and T5 revealed how their pre-test patronizing stance reflecting scientism had been largely replaced by a more accommodating and inclusive post-test stance i.e., they had become more appreciative of the worth of an integrated science-IKS curriculum than was the case before the course.

The teaching strategies that were ranked highest (1^{st} and 2^{nd}) by the teachers could be regarded as reasonable and acceptable in the light of current constructivist epistemology and pedagogy. The strategy involving argumentation was, however ranked very low (8^{th}) out of the top 10 instructional strategies. As the course both espoused and modeled argumentation as an instructional approach, we did not expect to see it ranked that low. Apart from the controversy surrounding C005 and the stranglehold effect of examination on the education system, a possible explanation could be that the notion of arguing within school classrooms (as opposed to graduate school sessions) is socially and/or culturally unconscionable. Generally, adults in this part of the world normally expect children to be seen and not heard, and obedience is usually manifested as unquestioning acceptance of the views of elders and superiors (especially teachers). It is also possible that exposure to a 6-month course involving argumentation as a teaching approach was simply insufficient to overcome deeply held social and religious beliefs. Despite the teachers' generally positive feelings towards the course, they were of the view that to succeed they would need additional long-term mentoring and supportive activities to augment the course. This view accords with recommendations made by researchers who have used this instructional approach (e.g., Erduran et al., 2004; Osborne et al., 2004; Simon et al., 2006).

The science teachers involved in this study were of the opinion that the course enhanced their understanding of the nature of science and IKS and how to integrate the two in their classrooms. All the teachers thought that the course made them more sensitive to the socio-cultural environment of their students. They all recommended the inclusion of the course or similar courses in science education courses designed for the training of prospective and in-service science teachers confronted with C2005. Among other gains, the course seems to have enhanced the teachers' willingness to implement a science-IKS curriculum in their classrooms. At this point and other than glimpses suggested in the delayed post-test NOS-IKS questionnaire, we have no evidence of our teachers implementing their ideas or the instructional strategies that they espoused. This remains a topic for further research. An observation of the actual teaching strategies used by the teachers after attending the course would provide more dependable assurance of the effects of the course on their knowledge, attitudes and skills concerning implementing an integrated science-IKS curriculum.

Conclusion

The study used a graduate level science education course based on argumentation theory to help school teachers accept the mandate of the new South African curriculum C2005 to integrate IKS into the science curriculum. After the course, the teachers: 1) showed more positive attitudes and inclinations towards a science-IKS curriculum; 2) were more able to distinguish between science and IKS; and 3) had become more aware when to use either or both systems of thought than was the case before the course. Although the teachers were generally enthusiastic about the value of the course as part of their training at the tertiary level, they were less optimistic about its effectiveness as an instructional strategy at the primary or secondary school level. It is hoped that the implementation of the A-B course to a larger cohort of teachers for a much longer period in the next phase of the study coupled with systematic mentoring would provide a clearer picture about the effectiveness or otherwise of the course.

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