LANGUAGE, CULTURE, ONTOLOGICAL ASSUMPTIONS, EPISTEMOLOGICAL BELIEFS, AND KNOWLEDGE ABOUT NATURE AND NATURALLY OCCURRING EVENTS: SOUTHERN AFRICAN PERSPECTIVE

CYNTHIA FAKUDZE* & MARISSA ROLLNICK**

**University of Cape Town, **University of Witwatersrand (South Africa)*

ABSTRACT. African students enter the classroom with a rich heritage of traditional beliefs that, if handled sensitively and with understanding, can play an important role in enabling learning of science. Recent developments in the understanding of how students acquire this knowledge may assist in promoting this process. This paper investigates studies situated within the worldview theory that examine the learning of science concepts within a Southern African sociocultural environment by looking at (a) the problems and solutions for students in such settings when they learn through a medium of instruction (L2 and L3) that is different from their first language (L1), (b) the nature of the worldview presuppositions held by African students on selected natural phenomena, and (c) the nature of cognitive border crossing exhibited by students from a Southern African traditional worldview to a western scientific worldview that forms the basis of a Cognitive Border Crossing Learning Model (CBCLM). Two important issues are explored in relation to the language issue: using a discourse-based model to show how accessing either spoken or written mixed discourse may facilitate learners' comprehension of scientific discourse and allow a teacher to assist in its production, and how code switching is a useful strategy to assist border crossing in the science classroom. The CBCLM is presented as a feasible way of describing how, when, and in what contexts a student shifts from one worldview to another during the learning process.

KEYWORDS: code switching, cognitive border crossing, cultural border crossing, border crossing, collateral learning, culture, language, science, worldview

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Correspondence concerning this article should be directed to Cynthia Fakudze, University of Cape Town, School Development Unit, Rondebosch, 7700, Cape Town, South Africa, Tel: 27.21.650.3850, Fax: 27.21.650.5330. Electronic mail may be sent to cynthia.fakudze@uct.ac.za.

Dutch
Samenvatting [Translated by Tanja Janssen]
Afrikaanse leerlingen komen de school binnen met een rijk erfgoed van traditionele opvattingen dat, indien met gevoel en begrip gehanteerd, een belangrijke rol kan spelen bij het leren van science. Recente ontwikkelingen en inzichten in hoe leerlingen deze kennis verwerven kunnen behulpzaam zijn bij het bevorderen van dit proces. In deze bijdrage gaan we in op onderzoek dat verricht is binnen de wereldbeeld-theorie. In dat onderzoek zijn begrippen op het gebied van science bestudeerd binnen een Zuid-Afrikaanse sociaal-culturele omgeving, door te kijken naar (a) de problemen en oplossingen voor leerlingen voor wie de instructietaal (L2 en L3) afwijkt van hun eerste taal (L1), (b) de aard van de wereldbeeld vooronderstellingen die Afrikaanse leerlingen hebben over bepaalde natuurverschijnselen, en (c) de aard van cognitieve "border crossing" door leerlingen, van een traditioneel, Zuid-Afrikaans wereldbeeld naar een westers wetenschappelijk wereldbeeld, die de basis vormt van een "Cognitive Border Crossing Learning Model" (CBCLM). Op twee belangrijke kwesties wordt nader ingegaan: het gebruik van een op communicatie gebaseerd model om te laten zien hoe toegang tot mondelinge of geschreven taal het begrip en de productie van wetenschappelijke taal kan faciliteren met de steun van de leerkracht, en hoe het veranderen van code een bruikbare strategie kan zijn om "border crossing" te ondersteunen in de klas. In het CBCLM-model wordt beschreven hoe, wanneer en in welke contexten een leerling van het ene wereldbeeld naar het andere overgaat tijdens het leerproces.
Keywords: van code veranderen, cognitieve *border crossing*, cultureel *border crossing*, collateraal leren, cultuur, taal, natuurwetenschappen, wereldbeeld.

French
Résumé [Translated by Laurence Pasa]
Les élèves africains arrivent en classe avec un héritage riche de croyances traditionnelles qui, s'il est utilisé avec sensibilité et compréhension, peut jouer un rôle important dans l'apprentissage des sciences. Les développements récents des travaux sur l'acquisition de ces savoirs peuvent favoriser ce processus. Le travail présenté s'intéresse aux études relatives à la notion de « vision du monde » qui examinent l'apprentissage des concepts scientifiques dans un contexte socioculturel sud-africain en considérant a) les problèmes rencontrés, et les solutions envisageables, lorsque des élèves issus d'un tel contexte doivent apprendre dans une langue (L2 et L3) différente de la leur (L1), b) la nature de leur vision du monde et des présupposés sous-jacents à l'égard de certains phénomènes naturels, et c) la nature des changements cognitifs que doivent opérer les élèves pour passer d'une vision du monde sud-africaine traditionnelle à une vision du monde occidentale scientifique, ce qui constitue la base du modèle théorique « Border Crossing Cognitive Learning Model » (CBCLM). Deux points importants sont examinés en relation avec la question du langage : l'utilisation d'un modèle centré sur le discours afin de montrer comment l'accès au discours oral et/ou écrit peut faciliter la compréhension du discours scientifique par les élèves et permettre à un enseignant de participer à sa production, et en quoi l'alternance codique est une stratégie utile pour favoriser les transitions cognitives durant le cours de sciences. Le modèle CBCL est présenté comme un moyen possible de décrire comment, quand, et dans quels contextes, un élève passe d'une vision du monde à une autre en cours d'apprentissage.
Mots-clés: alternance codique, transitions cognitives, transitions culturelles, apprentissage collatéral, culture, langage, science, vision du monde.

Italian
Abstract [Translated by Manuela Delfino].
Gli studenti africani iniziano la scuola con un ricco bagaglio di credenze tradizionali che, se gestite con delicatezza e cognizione di causa, possono svolgere un ruolo importante nel facilitare l'apprendimento delle scienze. La promozione di questo processo può essere aiutata dai recenti sviluppi nella comprensione di come gli studenti acquisiscano queste conoscenze. Questo articolo propone un'indagine sulle ricerche che si inseriscono nell'ambito della teoria della visione del mondo applicata all'apprendimento dei concetti scientifici nel contesto socio-culturale dell'Africa del Sud, focalizzando l'attenzione (a) sui problemi e le soluzioni per gli studenti che vivono in questo ambiente, quando imparano per mezzo di istruzioni (in L2 e L3) che differiscono dalla loro lingua madre (L1), (b) sulla natura dei presupposti della visione del mondo degli studenti africani su specifici fenomeni naturali e (c) sulla natura del superamento delle frontiere cognitive mostrato da studenti che, da una tradizionale visione del mondo sud-africana, migrano a una visione del mondo occidentale, un processo sulla cui base è stato sviluppato il Modello di

Apprendimento per l'Attraversamento di Frontiere Cognitive (Cognitive Border Crossing Learning Model, CBCLM). Due argomenti importanti sono esplorati in relazione al problema della lingua: l'uso di un modello conversazionale per mostrare come l'accesso a un discorso misto, sia parlato che scritto, possa facilitare la comprensione da parte degli studenti del discorso scientifico e permettere al docente di agevolare questo processo, e come la commutazione di codice sia una strategia utile per aiutare il superamento della frontiera cognitiva nella classe di scienze. Il modello CBCLM si presenta come un modo realizzabile per descrivere come, quando e in quali contesti uno studente in un processo d'apprendimento si sposti da una visione del mondo ad un'altra.
Parole chiave: commutazione di codice (code switching), superamento di frontiere cognitive, superamento di frontiere culturali, passaggio di frontiera, apprendimento collaterale, cultura, lingua, scienze, visione del mondo.

Polish

Streszczenie [Translated by Elzbiéta Awramiuk]
Afrykańscy uczniowie wkraczają do klasy z bogatym dziedzictwem tradycyjnych wierzeń, które – jeśli obchodzi się z nimi delikatnie i ze zrozumieniem – mogą odgrywać istotną rolę w stworzeniu odpowiednich warunków do uczenia się przedmiotów ścisłych. Najnowsze osiągnięcia w rozumieniu, jak uczniowie zdobywają tę wiedzę, mogą pomóc w działaniu na rzecz tego procesu. Niniejszy artykuł relacjonuje osadzone w teorii językowego obrazu świata badania, które analizują uczenie się pojęć naukowych w południowoafrykańskim środowisku socjokulturowym poprzez spojrzenie na (a) problemy i rozwiązania dla uczniów, którzy uczą się poprzez pewne pośrednictwo (L2 i L3), inne niż ich pierwszy język (L1), (b) naturę presupozycji obrazu świata, które afrykańscy uczniowie mają na temat wybranych zjawisk naturalnych oraz (c) poprzez naturę przekraczania poznawczych granic uzewnętrznianych przez uczniów podczas przechodzenia od tradycyjnego południowoafrykańskiego obrazu świata do obrazu świata zawartego w nauce zachodniej (co stanowi podstawę Modelu Uczenia się Przekraczania Granic Poznawczych – CBCLM). W relacji do kwestii językowych badane są dwa istotne zagadnienia: używanie modelu bazującego na dyskursie w celu pokazania, jak dostęp do mieszanego mówionego lub pisanego dyskursu może ułatwić uczniowskie zrozumienie dyskursu naukowego i jak umożliwia nauczycielowi asystowanie przy jego tworzeniu oraz jak przełączanie kodu może być użyteczną strategią pomagającą przekraczać granice na lekcjach przedmiotów ścisłych. Model CBCLM umożliwia opis, jak, kiedy i w jakim kontekście uczeń przełącza się z jednego obrazu świata na drugi podczas procesu uczenia się.
Słowa-klucze: przełączanie kodu, przekraczanie granic poznawczych, przekraczanie granic kulturowych, przekraczanie granic, poboczne uczenie się, kultura, język, nauka, obraz świata

Portuguese

Resumo [Translated by Paulo Feytor Pinto]
Os estudantes africanos chegam à sala de aula com um rico conhecimento de crenças tradicionais que, se forem cuidadosamente abordadas, podem ter um papel importante na facilitação da aprendizagem das ciências. Desenvolvimentos recentes na compreensão de como os estudantes adquirem este conhecimento podem contribuir para a promoção deste processo. Este texto aborda estudos, no domínio da teoria da mundividência, sobre a aprendizagem de conceitos científicos num contexto sociocultural sul-africano incidindo sobre (a) os problemas e as soluções para estudantes destes contextos quando aprendem através de um veículo de ensino (L2 e L3) que é diferente da sua língua materna (L1), (b) a natureza dos pressupostos da mundividência das crianças africanas acerca de determinados fenómenos naturais, e (c) a natureza da transposição cognitiva observada em estudantes que passam duma mundividência sul-africana tradicional para uma mundividência científica ocidental e que constitui a base do Modelo de Aprendizagem através da Transposição Cognitiva (CBCLM). Relativamente à língua, duas questões importantes são exploradas: o recurso a um modelo baseado no discurso para demonstrar como a avaliação de discursos mistos, tanto orais como escritos, pode facilitar a compreensão do discurso científico por parte do aluno e o acompanhamento da sua produção por parte do professor, e como a alternância de códigos linguísticos pode ser uma estratégia que contribui para a transposição cognitiva na aula de ciências. O CBCLM é apresentado como um modo exequível de descrição de como, quando e em que contextos um estudante muda de mundividência ao longo do processo de aprendizagem.
Palavras-chave: alternância de código, transposição de limites cognitivos, transposição de limites culturais, transposição de limites, aprendizagem colateral, cultura, língua, ciência, mundividência.

Spanish
Translated into Spanish by Max Vazquez from Benemérita Escuela Normal Veracruzana, Mexico
Resumen: Lenguaje, cultura, suposiciones ontológicas, creencias epistemológicas, conocimiento de la naturaleza y eventos naturales: una perspectiva de Sudáfrica
Los estudiantes africanos entran al salón de clases con una herencia de creencias tradicionales que, si son tratadas adecuada y sensiblemente, pueden jugar un papel importante para facilitar el aprendizaje de las Ciencias. Investigaciones recientes demuestran que la adquisición de conocimientos puede mejorar mediante el estudio de los procesos de aprendizaje. Este documento investiga estudios utilizando una teoría de perspectiva mundial que examina el aprendizaje de conceptos científicos dentro del contexto sociocultural sudafricano considerando (a) los problemas y soluciones para los estudiantes en tales escenarios cuando ellos aprenden a través de un medio de instrucción (L2 y L3) diferente de su lengua materna (L1), (b) la naturaleza de las presuposiciones con una perspectiva mundial que tienen los estudiantes sudafricanos al seleccionar un fenómeno natural, y (c) la naturaleza del cruce de fronteras cognitivas mostrada por estudiantes desde una perspectiva mundial tradicional sudafricana hasta una perspectiva científica occidental que forma la base de un Modelo de Aprendizaje de Cruce de Fronteras Cognitivas (Cognitive Border Crossing Learning Model, CBCLM). Dos aspectos importantes explorados en este documento que tienen relación con el lenguaje son: el uso de un modelo basado en el discurso para mostrar cómo el acceso a discursos mixtos (en L1, L2 y L3) en forma oral y escrita facilita a los alumnos la comprensión del discurso científico y permite al maestro asistir al alumno en su producción; y cómo cambiar de código es una estrategia útil para ayudar a cruzar fronteras cognitivas en el salón de clases. El CBCLM es presentado como una manera viable de describir cómo, cuándo y en qué contextos un estudiante cambia de una perspectiva mundial a otra diferente durante el proceso de aprendizaje.
Palabras clave: cambio de código, cruce de fronteras cognitivas, cruzar un nivel cultural, cruzar nivel, aprendizaje colateral, cultura, lenguaje, ciencia, perspectiva mundial.

1. INTRODUCTION

> The student in Africa has one name which is used at school and another which is used at home. There is one type of behaviour at school and one at home. There is one type of dress for school and one for home. There is a language for school and a language for home. Why not then two concepts of science?
>
> *(Rollnick, 1988: 232)*

Southern Africa includes fifteen countries where the majority of the people are Bantu-speaking. Bantu is a general term used for over 400 different ethnic groups united by a common language-family and customs. However, this paper will consider only eight groups that have English as one of their official languages and a variety of Bantu languages.

Country	*Languages*
Botswana	English, Tswana
Lesotho	English, Southern Sotho, Zulu, Xhosa
Malawi	English, Chichewa, Tumbuka, Tonga, Ngoni
Namibia	English, German, Afrikaans, Oshiwambo
South Africa	Zulu, Xhosa, Afrikaans, English, Northern Sotho, Tswana, Southern Sotho, Tsonga, Swati, Venda, Ndebele
Swaziland	English, Swati

Zambia	English, Bemba, Nyanja-Chewa, Tonga, Lunda, Luvale, Kaonde, Lozi
Zimbabwe	English, Shona, Ndebele

According to some African writers (Goduka, 1999), the knowledge systems of indigenous communities such as the ones listed are grounded in oral traditions that use mythology and legends rather than the Newtonian-Cartesian epistemologies of European culture. This knowledge formation has a direct bearing on the languages of these indigenous people in the sense that the terminology is embedded in cultural taboos and euphemism. The terms used do not have univocity as in western cultures, where a single term would have one concept. Because of these language issues and other factors, first language (L1) students from these cultures have difficulty in accessing school science that is taught in English and based mainly on a western worldview.

The paper will first look at how language issues have been dealt with in the teaching and learning of science in the Southern African context. Secondly, a description will be provided of the differences between African traditional and scientific worldviews. Finally, the paper will look at the different hypotheses that have been used in describing students' transition from their traditional worldviews found in their sociocultural environments into that of school science. Several studies will be used to illustrate these hypotheses. In short, the paper will try to answer the following questions:

- What language strategies are most effective as students in African settings are taught and learn through a medium of instruction (L2 and L3) that is different from their first language (L1) or mother tongue?
- What is the nature of the worldview presuppositions held by Southern African students on selected natural phenomena?
- What is the nature of cognitive border crossing exhibited by students from a Southern African traditional worldview to a western scientific worldview?

2. LEARNING AND TEACHING IN L2 AND L3 WITHIN AN L1 SOCIOCULTURAL ENVIRONMENT

Most learners in Southern Africa speak one language at home and are expected to study in a different language at school. The extent of separation of these two contexts is determined by whether the school is urban or rural. Cleghorn and Rollnick (2002) characterised the language of learning and teaching (primarily English in the region) in rural contexts as a foreign language; while in the urban areas where there is greater access to English language media, it is regarded as a second language. Nevertheless, the learning of science is further distanced from the home culture by its expression in either a second or foreign language, creating further logistical borders to be crossed. They presented the analogy of the schoolbag as the object that crosses between the two worlds – home and school – infrequently opened in the former context where chores and lack of electricity often obstruct the doing of homework.

Two theoretical perspectives have dominated research on language in science. Some researchers examine the use from a cognitivist perspective (e.g. Cummins, 1980; Bailey, Butler, LaFramenta, & Ong, 2001/2004), while other researchers approach it from a sociolinguistic point of view (e.g. Hymes, 1974). The sociolinguists have more recently been enriched by contributions from those operating from a situated cognition perspective (e.g. Gee, 1997), and it this viewpoint that is most consonant with the border-crossing perspective.

Both the cognitivist and situated cognition approaches originate from a constructivist theoretical framework. The cognitivist view focuses primarily on the learning of the individual while the situated cognition approach stresses the importance of the community in language use and understanding, claiming that knowing and understanding are fundamentally tied to the context in which it is produced. Cobb and Bowers (1999) provided some insight into the difference between the two perspectives.

Historically, the focus of cognitive psychology has been on words and concepts in the text while the focus of the sociocultural perspective is on the discourse employed and its relationship to the reader's social situation. Within the cognitivist approach, some proponents view reading as information processing (Rumelhart, 1980). Using this perspective, the challenge of improving learners' ability to access text becomes a case of helping with difficult words, improving readability of the text, lessening extraneous 'noise' (Johnstone & Wham, 1982), and, above all, simplifying language. Learners are assisted in achieving this objective through overt teaching. Others such as Bailey et al. (2001, 2004) explore the teacher's use of academic language in achieving competent academic language proficiency (Cummins, 1980).

Gee (1996), on the other hand, discussed acquiring discourse (academic discipline-specific discourse) that embodies much more than just language and words. Use of language is embodied in contexts that carry with them social mores and ways in which language is used. So it is possible to speak perfectly grammatically yet make utterances that are totally inappropriate to the situation. The implication for a learner accessing text is that, if the text is simplified to an extent that it no longer belongs to the discourse of the discipline being learnt, the learner will not be able to function in the social practice of the discipline – border crossing will not be possible in order to participate in the discipline. Gee distinguishes acquisition and learning as two different activities. He maintains that to enter the discourse of the discipline a learner has to *acquire* the language, social practice, and functioning of the group by participation involving trial and error in natural settings. Alongside acquisition, learning can occur; but learning is primarily a process of gaining meta-knowledge, primarily about the differences between the discourse to be acquired (Gee refers to this as a secondary discourse) and the learner's primary discourse (the language the learner already has in relation to the community he/she comes from). Both Gee (2005) and Bailey et al. (2001/4) recognise the importance of academic language in the context of learning science from different perspectives. While Bailey et al. (2001/4) emphasise the decontexutalised nature of academic language, Gee (2005)

identifies it as a social practice in itself, providing its own context and requiring a social cost to the learner in seeking to join that practice.

Block and Rollnick (2003) quoted a novice lecturer in a geography course at a historically disadvantaged South African institution who reads directly from a study manual in his lecture:

> ... cold temperatures may result in death due to cell destruction by freezing or complete desiccation of plant tissue.

The bulk of the lecture consisted of reading sentences like the one above, but here the lecturer makes a rare pause to attempt to unpack the sentence. He continued:

> Now, what does desiccation mean? What does desiccation mean? Any response? What does desiccation mean? ... [silence] They're saying cold temperature may result in death due to freezing or complete desiccation of plant tissue ... So what I am saying is, what does desiccation mean? Any idea? ... [silence] What does desiccation mean? Cold temperatures may result in death due to the cell destruction by freezing or complete desiccation of plant tissue, that is, complete desiccation of plant tissue, complete destroyal of plant tissue.

The phrases from the manual are repeated like a mantra, apart from the slightly inaccurate paraphrase in the last sentence. But no response is forthcoming from the students. Is a response expected? How would the students respond to a simpler text? Should the text be simplified? Do we defeat the purposes of teaching science by doing so? The lecturer in this case has learnt but not acquired the discourse and hence has difficulty in paraphrasing the sentence. Rather, he repeats the phrases over and over, hoping they will become clearer to the students. Once the meaning of the sentence is clearer, the students will still be expected to show their membership of the academic community by producing the required discourse.

Gee (2005) used the concepts of *life world language* and *academic social language* to highlight the distinction between everyday language and the language of science. His emphasis is on the acquisition of academic social language by learners who use the language of learning and teaching (in this case, English) as their main language. The question raised here is different since it concerns learners who are learning through the medium of a language that is not their primary language. Gee maintained that, in order to become part of the scientific community, learners must be able to use academic social language or they will not become part of the community of practice, in this case of science.

Gee identified various characteristics of scientific discourse that distinguish it from everyday discourse. In many cases, the object of interest in scientific discourse changes from being a person to an abstract entity. For example, the phrase above (cold temperatures may result in death due to cell destruction by freezing or complete desiccation of plant tissue) can be translated into what Gee called life world language as *Plants will freeze to death in cold weather because their cells will dry out*. Much of the scientific message is lost, and the focus has changed from the effect of the low temperatures on plant cells to the fate of the plants. Thus, in terms of this perspective, for learners to acquire scientific discourse, texts need to use the language of scientists.

Using language involves both accessing discourse and producing discourse. Listening and reading would require accessing discourse, while speaking and writing are the primary means of producing discourse. Learners who can paraphrase the discourse meaningfully in life world language have successfully accessed the discourse but have not necessarily displayed the ability to produce the required academic social language. To become part of the community of practice, this last step is essential (Florence & Yore, 2004).

Rollnick (2004) proposed a model for accessing text where she shows that the use of mixed discourse in text may be a productive way of assisting border crossing into science. The model stops short of code switching (Cleghorn & Rollnick, 2002) in written form but allows a form of managed border crossing that may assist transition between the discourses. The model uses an intermediate form of life world language referred to as second language discourse, which would be understood only in the local discourse community but would be understood by an English speaker as a local dialect of English. An example of this discourse would be *my mother is late* meaning *my mother has passed away*. This form of life world language would be more easily acquired by non-speakers of the primary language who may be teaching science to these learners.

The model has been adapted here to show how accessing either spoken or written mixed discourse may facilitate learners' comprehension of scientific discourse and allow a teacher to assist in its production. The starting point would be materials or utterances by the teacher that make use of both life world language and academic social language. Rollnick, Green, and Block (2003) used an approach in writing distance materials that provides a mixture of discourses with the new scientific discourse carefully mediated in the text, as the following edited extract on solutes and solvents shows:

> In your everyday life you are used to making solutions. When you take sugar (the solute) and dissolve it in your tea (the solvent), you are, of course, making a solution. Another solution that is easy to make at home is one involving solid table salt (NaCl) and water. You could make a 1-litre solution of NaCl in a bottle, and you could choose to make your solution either concentrated or dilute, depending on much salt you use. A solution that contains a high proportion of solute compared to solvent is said to be *concentrated*. A solution that contains a little solute mixed with a lot of solvent is *dilute*.

The section begins by using life world discourse referring to familiar contexts, such as making a cup of tea. The point of the passage is to teach the concepts *concentrated and dilute* and *solute and solvent*. Of interest are the last two sentences, the first is in academic social language, and the second is in life world language. In this way, it is hoped that learners will be able to differentiate between the two ways of expressing parallel ideas. Learners were asked to paraphrase the last sentence in the text above. Responses fell into roughly three categories:

1) Those who were beginning to appropriate scientific discourse. Mostly these learners adopted the strategy of using the phrasing of the last section, e.g., the mixture of a solute and solvent where the solute has a low proportion.
2) Those who used life world language to rephrase, e.g., when you have a litre of water and you dissolve a teaspoon of sugar what is formed is a dilute solution.

3) Those who used second language discourse. The syntax looks rather strange to those outside the discourse community, e.g., the substance that is dissolved in another one when it's less than the one that is dissolved in the solution is called a dilute solution.

Within these categories, other practices such as rephrasing using an example were also observed. There were also responses that showed an understanding of the sentence that was different to that of the scientific community. Everybody showed some understanding of the sentence. What is interesting about these findings is that the use of a sentence in life world language immediately followed by one in academic social language did not prevent any learners from accessing the text but had the effect of gradually introducing the discourse necessary for the discipline. The evidence above shows that the learners were able to understand the text, though not necessarily actively produce the language themselves. So the life world language of the first language speaker becomes a meeting point for the teacher and the learner on the road to production of academic social language. Figure 1 shows how production from the text or spoken language may be modelled.

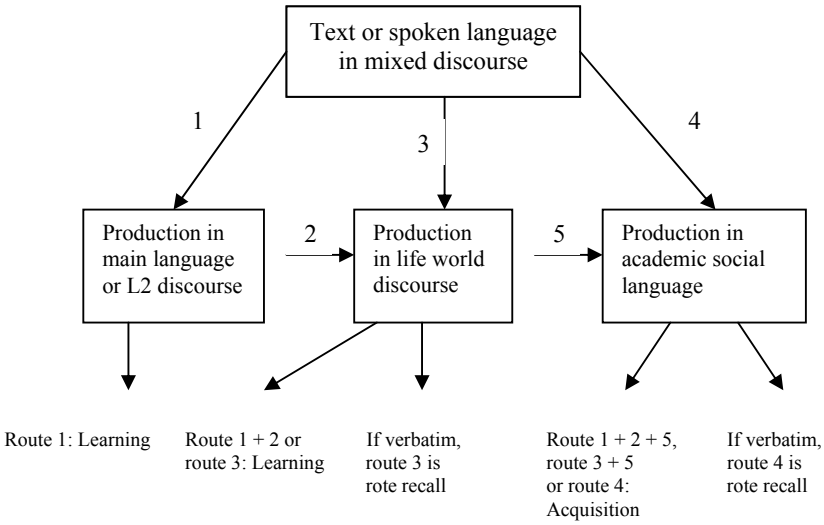

Figure 1. Meaningful production from text in mixed discourse.

Figure 1 shows a situation where the original text is written in mixed discourse. There are three possibilities for production arising from this text – use of main language or second language discourse as illustrated above, life world language or academic social language. Verbatim productions from the latter two (routes 1 and 4) would easily be detected as rote recall. If productions are not verbatim, the possible routes for acquisition and learning (routes 1, 1+2, 3, 1+2+5, 3+5, 4) are similar to those that could have arisen if the original text was in academic social language, but they are more likely to occur with mixed language discourse.

Duran, Dugan, and Weffer (1998) offered a route for making rote reproductions meaningful that resonates well with a discourse approach. They maintain that the use of academic social language in formal instruction is important for what they call *ventriloquation* of science language. The learners in their study were studying in their second language and were able to become users of the language even if they were insecure in the comprehension of the concepts in the early stages of mediated instruction. Learners at the beginning of their study viewed contextualisation of concepts as deviation from the business of learning biology; by the end of the study, they were able to contextualise concepts for themselves and use the language of the discourse. This study shows that learners may start using academic social language by merely imitating the discourse to which they are exposed. This discourse later becomes meaningful through its use in practice and is thus acquired. An important prerequisite for this type of acquisition is continuous exposure to the discourse by competent practitioners. In the context that second language learners often access texts, this exposure is not available; hence, a mediated route is necessary with conscious pointers to the differences between the discourses.

Whatever strategies are adopted to mediate the crossing from life world discourse to academic social language, it has to be acknowledged that in the Southern African region English is the language of power. While learners' first languages need to be affirmed, they are usually asked to display their knowledge and understanding in the language of public assessment – English. In practice, therefore, much classroom instruction is conducted in parallel languages; and the movement between languages is known as code switching.

2.1 Code Switching

Code switching has proved to be a valuable resource for constructing meaning in multilingual classrooms as it offers additional possibilities for richer communication. The discourse can be either life world discourse or academic social language, as each is possible in both languages. Although teachers often seem to hold negative attitudes about code switching, it has been shown that code switching can offer an effective resource to establish meaning in classrooms where the teacher and the students are able to communicate in the same home or main language (Adendorff, 1996; Eastman, 1992). Code switching is especially useful when either the learners' or teacher's English vocabulary is limited, making it difficult for them to reformulate ideas.

Cleghorn and Rollnick (2002) made the point that code switching can facilitate the establishment of meaning by providing a linguistic and cultural bridge to understanding. Sometimes only a word or two is necessary to provide an English term where the word does not exist in the local language, as in this example from the Rollnick and Rutherford (1996) study carried out in Swaziland. [Words spoken in English appear in italics in all the examples that follow; English translations of African languages appear in bold type.]

C: *Yes*. **Like in Mbabane. High atmospheric pressure goes** *with low altitude*, **right**?

B: **Yes**.

C: *So it means that the air would decrease in the bottle, causing it to collapse. And if you take it to a place of low atmospheric pressure, it will expand.*

Often, switches occur with words that seem irrelevant to the discourse; for example, phrases like, *isn't that so* or *you know*. Small switches such as these have the effect of capturing the attention of learners and refocusing their attention on specific content (Gumperz, 1982), as in the example below (Rollnick & Rutherford, 1996).

T: *They are made of air*. **Isn't that so**? [*spoken in SiSwati*]

In a study of South African grade 12 learners in an urban context, Mumba, Rollnick, and White (2002) observed teachers switching for the purpose of recalling prior knowledge.

T: *How can you test for an acid?*

S1: **By using indicators**

T: *Of course*, **when the indicators are added to acids, the colour changes.**

T: *Next property*

S2: **They react with metals to give a salt and hydrogen gas.**

T: **You must remember a metal and acid give you a salt and hydrogen gas.**

The foregoing example suggests the many forms and functions of code switching as well as its potential. These include clarifying linguistically based confusion; rendering the culturally unfamiliar, familiar; making the implicit, explicit; providing English vocabulary needed for examination purposes; providing contextualisation cues; and raising learners' metalinguistic awareness. Clearly, single instances of code switching often have more than one purpose. It would appear, however, that the full potential of code switching has yet to be fully identified and its functions categorised so that it can be used systematically and with greater consciousness than is usually the case.

3. THE EFFECT OF WORLDVIEW ON SCIENCE CONCEPT ACQUISITION

The concept of worldview has been defined in a variety of ways. This paper will adopt Cobern's definition (1993) that regards worldview as a culturally dependent, generally subconscious, fundamental organization of the mind, which manifests itself as a set of presuppositions that predisposes one to feel, think, act, and react in a certain predictable manner. There are numerous worldviews, but this paper will explore only two: traditional and scientific. A traditional worldview is a system of thought that is anthropomorphic, monistic, and metaphysical in nature (Jegede, 1997, Ogunniyi, 1988). It seeks mythological generalizations and is rational, prag-

matic, unequivocal, authoritative, experiential, non-testable, and non-falsifiable (Ogunniyi, 1987, 1988, 1995). It is based on people, is orally communicated, and considers the elder's exposition as truth not to be challenged (Jegede, 1997; Ogunniyi, 1988). It views learning as a communal activity. A classic scientific worldview, on the other hand, is a system of thought that is mechanistic in nature (Jegede, 1997, Ogunniyi, 1988). It is based on things and seeks empirical laws, principles, generalizations, and theories (Jegede, 1997; Ogunniyi, 1988). It is testable, falsifiable, tentative, revisionary, anti-authoritarian, impersonal, and challengeable by all (Jegede, 1997; Ogunniyi, 1988, 1995). It is primarily documented via print and views learning as an individual enterprise (Jegede, 1997).

According to the sociocultural constructivist view, students hold certain prior worldviews, which they have acquired from their sociocultural environment. The students' understanding of natural phenomena is conditioned by their worldviews, whether or not such views accord with valid scientific viewpoints. These worldviews are responsible for the students' disposition to the study of science, especially in the case of non-western students. Current research suggests that science teachers and students who are exposed to traditional (indigenous) wisdom and who have some level of commitment to it are likely to find that, to some extent, they are required to function in two worlds: the traditional world and that of science (Jegede, 1995). The differences in the worlds would require them to move back and forth from one worldview to another.

Aikenhead (1996) argued that students' experiences with school science are considered in terms of students crossing borders from the subcultures associated with their sociocultural environments into the subcultures of science. As students move from one subculture to the other, they intuitively and subconsciously alter certain beliefs, expectations, and conventions. This implies that it is possible for non-western students to perform well in a western classroom without imbibing or being enthusiastic about displaying the associated values and attitudes. Aikenhead (1998) had summarized Costa's (1995) categories of student characteristics in a context of cultural border crossing as follows: (1) Potential Scientists cross borders into school science so smoothly and naturally that the borders appear invisible; (2) Other Smart Kids manage their border crossing so well that few express any sense of science being a foreign subculture; (3) 'I Don't Know' Students confront hazardous border crossings but learn to cope and survive; and (4) Outsiders tend to be alienated from school itself and so border crossing into school science is virtually impossible.

In an attempt to explain this phenomenon, several hypotheses have been proposed to explain how students move between their everyday life world and the world of science, and how they deal with cognitive conflicts between these two worlds, e.g., Cultural Border Crossing Hypothesis (Aikenhead, 1996), the Collateral Learning Hypothesis (Jegede, 1995), and the Contiguity Learning Hypothesis (Ogunniyi, 1995). These three hypotheses form the basis for the Cognitive Border Crossing Learning Model (CBCLM) used in a later section. For the purposes of this paper, the following operational definitions based on the three theoretical constructs will be used:

- *Border Crossing:* crossing borders from the subcultures associated with sociocultural environments into the subcultures of science the shift (Aikenhead, 1996)
- *Cultural Border Crossing Hypothesis*: Aikenhead's hypothesis on border crossing
- *Contiguity Learning*: The process whereby the co-existing traditional and scientific worldviews dynamically compete, supplant, or dominate one another in/after the learning process, depending on the worldview template serving as a frame of reference in a given context (Ogunniyi, 1995).
- *Collateral Learning*: A process whereby a student constructs, side by side and with minimal interference and interaction, scientific and traditional meanings of a simple concept during/after a learning process (Jegede, 1995).
- *Cognitive Border Crossing*: The cognitive shift from a traditional worldview to a scientific worldview that takes place during/after a learning situation as described in the CBCLM (Fakudze, 2003).

Although the Cultural Border Crossing Hypothesis has been able to identify the different types of border crossings experienced by students in the science education enterprise, it has not provided a description of *how* students undergo the transition from one worldview to another. What is more, the categorisation of students into *potential scientists, other smart kids, 'I don't know',* and *outsiders* gives one the impression that these categories are fixed, denying students the chance of changing from one to the other. This also implies that learning in science is a process that is not dynamic. Furthermore, the construct has not considered the issue of language, which plays a very important role in the acquisition of science concepts.

Even though the Collateral Learning Hypothesis has aptly identified the different types of collateral learning experienced by non-western students, it has not described how students acquire each one of them. It is also not clear whether or not students remain fixed in one type of collateral learning or they can move from one to the other, depending on the concept being learned. Once again, the issue of language has not been considered.

Unlike the Cultural Border Crossing and Collateral Learning hypotheses, the Contiguity Learning Hypothesis has been able to describe in general terms how the transition from one worldview to the other is likely to occur. However, it has been unable to spell out how and under what conditions the different types of border crossings and collateral learning are likely to be acquired by non-western students. Again, the Contiguity Learning Hypothesis has not considered the issue of language.

4. THE NATURE OF THE WORLDVIEW PRESUPPOSITIONS HELD BY AFRICAN STUDENTS ON SELECTED NATURAL PHENOMENA

Fakudze (2003) explored the nature of the conceptions held by 128 Swazi secondary school students (Year 4) of selected natural phenomena. The study used My Idea About Nature (MIAN), which is composed of eight fictitious stories about selected natural phenomena (Ogunniyi, 1999). Students had to express their agreement, dis-

agreement, or uncertainty with respect to five plausible explanations provided for each story. The subjects' responses to eight fictitious stories were grouped into five major themes or categories: magic and mysticism; metaphysics, parapsychology and pseudo-science; spiritism; rationalism, and science (Ogunniyi, Jegede, Ogawa, Yandila, & Oladela, 1995). The findings of this study revealed that the subjects regardless of sex, age, and interest in science held varying degrees of traditional as well as scientific notions about selected phenomena, that is, they hold a multiplicity of worldview presuppositions.

The first fictitious MIAN story dealt with the disappearance of people and animals in the Mantjolo dam. One of the options for this story stated that a seven-headed snake was responsible for the disappearances. Almost half (49%) of the students agreed with this option, typified by the following examples:

> *Because the people disappear without any trace on entering the dam without permission from the clan, this means that the seven-headed snake take them if it is not asked or told that someone has asked to enter the dam, it thinks its food for it*

> *The people and animals have been taken by the snake that the Mnisi clan believe or worshipped and it is the way the Mnisi clan fed the snake*

It is apparent that these respondents adhere to the beliefs of their communities that have been passed down over many generations. The above statements also seem to corroborate the views of Adeyinka, Kyeleve, and Yandila (1999) who would have grouped this phenomenon under superstitious beliefs. Such beliefs relate to strange but observable events that generate fear in the observers, leading them to give inaccurate explanations of such events or to attribute the former to unseen forces and supernatural agents. However, not all of the students adhered to traditional beliefs. Some of them believed that such stories were superstitious. Those that disagreed with the above mentioned story argued that:

> *There is no snake that can be owned by somebody and live in natural habitat*

> *I don't think that the is an thing like a snake staying in water but people only fail to swim across [sic]*

Another fictitious story of the MIAN was about a Swazi girl who was cured of acute hysteria (lihabiya) by traditional healers (tinyanga). According to Marwick (1966), the lihabiya came as a result of a spell cast by a man who had been rejected by a girl to whom he had been making advances. The first option for the story stated that the girl could not be cured in a hospital but was cured by a traditional healer because traditional medicine is superior to modern medicine. The second option stated that a traditional healer cured her because the tinyanga always know the cause of every disease. The third option stated that modern doctors could not detect activities of devils as tinyanga do. The fourth option stated that traditional healers do not deal only with things that can be seen but also those that cannot be seen.

From the results, it seemed that the students held diverse worldviews about the phenomenon since they agreed with two of the options as well as disagreed with the

other two, thus portraying a traditional worldview that is influenced by spiritism. One of their comments on the fourth option was as follows:

> *Traditional healers are always shown the right medicine to cure a patient by their bones they are using. Their bones contains messages from sleeping people (emadloti)*

Some of the students who disagreed that traditional medicine is superior to modern medicine and that traditional healers are always conversant about the cause of every disease based their arguments on hygiene, level of education, and lack of research techniques. They argued that:

> *Traditional healers is not of good health because they prepare muti and it can be used after two years, their place is not clean and they can transmit the disease by using the same razors on every person they heal rather than in hospitals every equipment that was used is kept safely and dumped safely and their environment is clean*

The students' responses are a reflection of the debates that have taken place in non-western traditional societies. Some researchers working in these traditional societies have argued that traditional knowledge has contributed to society in many ways (Davis & Ebbe, 1995; Goode, 2002; Iwu, 1995; Zangari & Marchdo, 2001). According to Iwu (1995), traditional knowledge is of great value in its contribution to health and medicine. He argues that:

> The only thing that you can say that traditional medicine has in common with modern medicine is the fact that they both cure disease – one heals, the other treats. But, the role of the traditional healer is much broader than that of a Western medical practitioner. The traditional doctor is a healer, diviner, adjudicator, and a protector of his whole community. Therefore, it is only a part of the traditional healer's role that we are discussing when we compare them to modern doctors. (Iwu, 1995: 12)

Snively and Corsiglia (2001) added that there are many traditional peoples' scientific and technological contributions incorporated in modern applied sciences (e.g., medicine, engineering, architecture, plant breeding, and so forth).

On the other hand, some researchers classify traditional beliefs as superstitions (Adeyinka et al., 1999; Emereole, 1998; Emereole, Munyadzwe, Ntingana, & Mosimakoko-Mosalakgoko, 2001). According to the American Heritage Dictionary of the English Language (Morris, 1982: 1292), superstition is:

> A belief that some action or circumstance not logically related to a course of events influences its outcome. [It is] any belief, practice, or rite unreasoningly upheld by faith in magic, chance or dogma.

Adeyinka et al. (1999: 130-131) argue that, in view of the fact that superstitions are not scientific but based mostly on magical, mystical, and irrational conceptions, and since they form an important component of alternative conceptions, it is essential for schools as "critical agents of change to disengage the minds of students from such erroneous beliefs … in order to prevent interference with learning the science process."

Some of the students from the Fakudze (2003) study mentioned above seemed to have turned against the traditional beliefs prevalent in their communities. These students even referred to their own indigenous beliefs as superstitions and argued that

education ought to change their cultural beliefs. The following excerpts from a videotaped group discussion illustrate this perspective graphically:

> *Thoko: I just like to tell you that we adopt these beliefs from our forefathers but that we have to come out from this thing. It will affect our future ...*
>
> *Vusi: We are Swazis. ... we must do your cultural beliefs at anytime if you want to do. Does this mean that we have to change our cultural beliefs?*
>
> *Thoko:Yes we are Swazis but we have to ... Now we are educated. Our forefathers were not educated that is why they believed that. No, we are not supposed to change our culture but we have to see something that is not true.*

The study concluded that these students were not immune from alternative worldview presuppositions, which probably exerted influence on their behaviours in certain contexts. Furthermore, these findings seem to corroborate earlier findings in the area, namely: (a) that students' worldview presuppositions tend to condition their understanding of natural phenomena, although such views may not accord with a valid scientific view (Ogunniyi, 1995); and (b) that the conceptions held by non-western students (in this case Swazi secondary school students) prior to formal instruction may, in part, be the result of traditional practices and beliefs existing in their communities and to which they were firmly committed (George, 1999; Lawrenz & Gray, 1995; Ogunniyi, 1995).

5. THE NATURE OF COGNITIVE BORDER CROSSING EXHIBITED BY SOUTHERN AFRICAN STUDENTS

Several studies conducted in Southern Africa have found that students from traditional societies do not completely abandon their traditional beliefs in favour of scientific ones in a learning situation, but instead tend to seek ways of holding onto both belief systems in one way or another (Gunstone & White, 2000; Jegede, 1995; Ogawa, 1986; Ogunniyi, 1995). These students are constantly faced with the challenges of crossing borders from the traditional worldview of their communities to the scientific worldview taught at school. In many instances they find themselves having to undergo various forms of contiguity learning, collateral learning, and border crossing in order to fulfil the school's requirements.

Fakudze (2004) illustrated the relationship between *secured collateral learning* and *managed border crossing.* At the end of a physics course on the topic of efficiency, a story was narrated to the students about a man who had been cursed by a witchdoctor after their quarrel at a drinking spree. The man was later sacked from his job by his foreman because he was no longer cutting the number of required trees. The students were asked to discuss among themselves whether the sacking was due to the witchdoctor's curse or to the inefficiency of the man's electric saw. One of the students argued as follows:

> *Langa: But as far as I am concerned, the fact that the oil was old also contributed to the efficiency of the machine. Although the oil was also old it means that the machine was working not in the right condition because it was consuming less oil, which is old, and*

> *also producing less work. Then on the other side the inyanga's evil had influence on him. He puts the spirits of forgetting on him. Mr. Ngwenya was thinking about the inyanga. The inyanga worked on Mr. Ngwenya.*

When applying Jegede and Aikenhead's (1999) claim on the relationship between *secured collateral learning* and *managed border crossing* to the above excerpt, it seems as if Langa *managed* to cross the border between his traditional worldview and that of school science. This is because he was able to explain, using scientific concepts, that the saw's inefficiency produced less work. However, he appears to *consciously* hold on to his traditional belief that the inyanga had bewitched Mr. Ngwenya by putting the spirits of forgetting on him, thus exhibiting secured collateral learning. Kuper (1986) suggested that Swazis believe in two types of witch doctors: the inyanga (traditional healer) and the umtsakatsi (sorcerer, wizard, or witch). They are contrasted on the grounds that "the inyanga helps" and the "the umtsakatsi destroys people"; one is good; the other is bad (Kuper, 1980: 172). The Swazis believe that nothing is beyond the power of the umtsakatsi, who can even use witchcraft to send sickness to enemies (Marwick, 1966). The inyanga described above is an umtsakatsi and would probably fall under the sorcery category.

Brown, Muziramba, and Pabale (2006) studied Zimbabwean and South African students' conception about lightning and reproductive health and found that students relied on collateral learning to resolve the conflict existing between their traditional and scientific worldviews. In the case of lightning, the students' responses revealed that they were of the opinion that there were two types of lightning: natural lightning, namely *legadima* in Sepedi (from God) and *tladi* (caused by people/bird/lizard). Brown et al. (2006: 214) wrote that:

> After students were taught about electric discharge using a Van Der Graff generator, their responses showed that some were able to recognise lightning as an electric discharge, but the majority still believed that people could manipulate lightning. Although a few seemed convinced that it was not possible for people to control and direct lightning, further probing revealed that they constantly vacillated between explanations proffered by the two world-views. This reflected a high level of uncertainty, with some students feigning successful movement into the culture of science just to please the teacher.

The last sentence could be interpreted as an illustration of the Contiguity Learning Hypothesis in that the students experienced the dynamic interplay between or among dominant mental states constituting the worldview template that probably governed their thoughts and actions (Ogunniyi, 1995). Perhaps their traditional worldview, commonsensical knowledge, and the scientific worldview are being repositioned such that they ultimately lay contiguously. In other words, a sort of cognitive wrestling of schemata was probably occurring (Adams, 1999; Ogunniyi, 1995) that eventually capitulated to the dominant one – in this case, the scientific worldview in order to please the teacher.

Sadeck (2006) explored preservice science teachers' physical notions and traditional ideas about heat and temperature. One respondent agreed with both the traditional and scientific worldviews about how babies catch a cold. In the latter he agreed that the cold is due to witches entering the baby's head as well as dew falling

on the baby's head at night. He substantiated his statement by adding, "My mother used to say – at night if you open the baby, the evil spirits will come." (Sadeck, 2006: 622). He also agreed with the scientific worldview that viruses are responsible for colds. Sadeck (2006: 622) argued that the respondent:

> … does not seem to be experiencing cognitive dissonance. He readily 'accepts' the scientific view as presented. His explanation of how he accesses knowledge for a test seems to verify Ogunniyi's idea of Contiguity (1996) and Jegede's idea of Collaterality in that both the everyday worldviews and the scientific view seems to be contiguously juxtaposed.

Sadeck concluded that the students (a) did undergo border crossing, (b) were able to hold both views simultaneously without interaction, and (c) experienced contiguity, i.e., interaction between the two worldviews where the selected worldview is often chosen on the basis of the human interest being served (Ogunniyi, 2002). Parallel Collateral Learning is also evident in that he held onto both worldviews without them interfering with each other.

Cameron, Rollnick, and Doidge (2005) asked a group of university students in a foundation course in basic astronomy: What is a star? One student responded that he had been told as a child "… that each star represents a person who died. When they go up to heaven, they look at the earth through the star (the stars are like the eyes of the people who have passed away)" (Cameron et al., 2005: 8). The student added that he did not know the scientific explanation for what happens to the stars during the daytime but under 'personal understanding' wrote:

> During the night they disappear because the dead people sleep and wake up during the night as stars to watch over us while we sleep. (I don't believe this; it's just that my grandparents told me because I asked them lots of questions). (Cameron et al., 2005: 8)

Cameron's subject seemed to have undergone *hazardous border crossing* that resulted in Dependent Collateral Learning in that he was still not certain about the scientific explanations about where stars went at daytime. The stored information in long-term memory was at a tentative status awaiting new information that might sway him in either scientific or traditional worldview direction depending on the dominating worldview.

6. THE COGNITIVE BORDER CROSSING LEARNING MODEL (CBCLM)

It was observed that applying the concepts of border crossing, contiguity learning, and collateral learning separately does not fully describe what goes on in students' minds as they are confronted with a worldview that either contrasts or collaborates with their existing conception, one acquired from their sociocultural environment. Therefore, the Cognitive Border Crossing Learning Model (CBCLM) (Fakudze, 2004) was proposed, which combines three theoretical models (Cultural Border Crossing, Collateral Learning, Contiguity Learning) to show how, when, and under what conditions the various types of border crossings and collateral learning might occur within the mind of a student living in an African sociocultural context. The

border crossings in the model are seen as cognitive border crossings and will be designated as such within each description of the subcategories.

The CBCLM (Figure 2) uses the information-processing model depicted by Eggen and Kauchak (1994) and Johnstone (1997) as its basic framework. It is divided into three main parts: Sensory Register (SR), Working Memory (WM) otherwise known as short-term memory, and Long-Term Memory (LTM), which are joined by arrows. Attention (A) and Perception (P) stages are shown in the model. The diagonal line across the WM box shows the divide between traditional and scientific worldviews. The area in each section is proportional to the dominating worldview (i.e., the bigger the area, the more dominant the worldview). The two horizontal lines within the WM box show the division between commonsense-intuitive knowledge and the other two worldviews. The area within this section is proportional to each worldview (i.e., commonsense-intuitive knowledge is dominant, while the scientific and traditional worldviews are equal but recessive). The arrows between the WM and LTM illustrate the various types of border crossings that can occur when information is transferred from WM into LTM. The four divisions within LTM represent the four types of collateral learning.

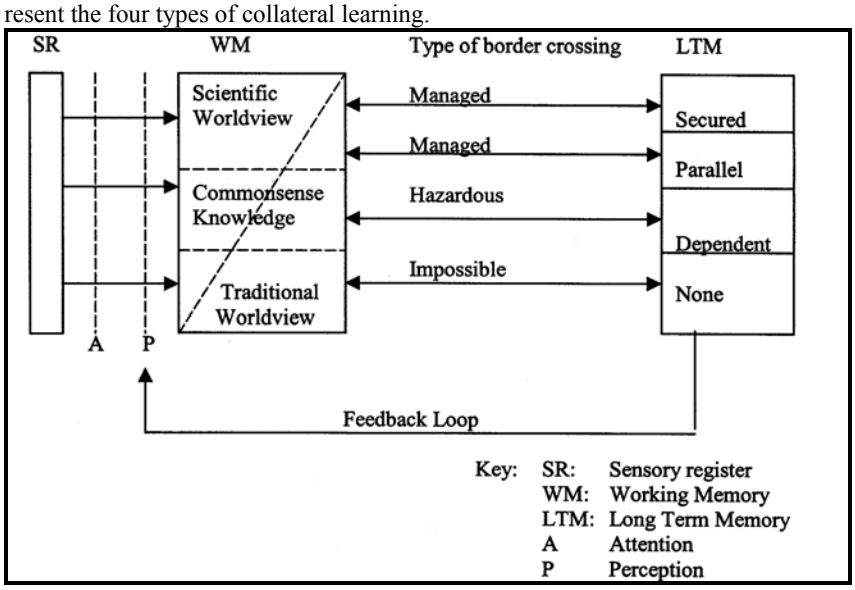

Figure 2. The Cognitive Border Crossing Learning Model (CBCLM).

6.1 Cognitive Border Crossing in Terms of the CBCLM

When students in a science classroom receive a science concept through the SR, they contrast it with already existing information retrieved from their LTM. Some contiguity learning takes place as the worldviews meet and seek natural points of

contiguity (i.e., regions in the two thought systems sharing common elements) in order to accommodate, reconcile, and adapt to each other. The students' traditional beliefs as well as their commonsensical-intuitive knowledge are contrasted with the scientific concept encountered in the science classroom and given a tentative status. The concepts from the science lesson and from LTM now lie contiguously; and information is then processed by recalling, relating, collaborating the new with the old knowledge. In another sense, the views also tend to compete, supplant, and dominate one another in the learning process, depending on the worldview template serving as a frame of reference in the given context (contiguity learning). This results in one worldview dominating the others, thus leading to the process of transition (border crossing) and storing (collateral learning) in LTM. Four types of cognitive border crossings and collateral learning can take place after that, depending on the resultant dominant worldview (refer back to the above examples).

A study on the cognitive border crossing between a religious worldview and scientific worldview conducted by Fakudze and Holtman (2003) on a class of Zoology students will be used to illustrate each subsection. The religious worldview is hereby categorized under traditional worldview and treated as such.

6.1.1 Managed/Secure Cognitive Border Crossing

Managed/secure cognitive border crossing occurs when the scientific worldview schema is dominant and the learned concept can be linked to a reasonable number of networks already in LTM. In this case, incoming encoded information will find a good fit to existing knowledge in LTM. Retrieved information from LTM may have elements of both scientific and traditional worldviews. Students are swayed more toward the scientific worldview after the lesson and emerge with a valid, scientific conception of the issues. The results of the Fakudze and Holtman (2003) study showed that some of the students held both a scientific worldview and religious worldview before the evolution module and were later swayed more towards the scientific worldview after the module, emerging with a valid scientific conception of evolution and related concepts as illustrated in this excerpt:

> *Researcher: So when you go into class, what do you do to your beliefs? Do you put them aside or whatever?*
>
> *Samu: Not really, like I said I'm open-minded. So I always have my beliefs at the back of my mind. I listen and I grasp to have they have to say and I only take what I believe I can take. And what I don't want to take I don't take. But I just don't argue with them. I choose not to, I don't compare it. I just take whatever thing has reason and whatever I think, "this I can take and this-no, it is just far"*

6.1.2 Managed/Parallel Cognitive Border Crossing

Managed/parallel cognitive border crossing occurs when the scientific worldview schema is dominant and the learned concept can be linked simultaneously with related traditional worldview schema to a reasonable number of networks already in

LTM. In this case, retrieved information from LTM was originally of a traditional worldview. Students start with a traditional worldview or are unsure of the answer before the science lesson and end up with a valid scientific conception but stuck to their traditional worldview. Such students are open-minded and want to know more about the scientific worldview without, however, altering their traditional worldview. Some students in the Fakudze and Holtman (2003) study underwent managed/parallel cognitive border crossing because they either started with a religious worldview or were unsure of the answer in the pre-test and ended up with a scientific worldview after instruction. These students usually become open minded about new concepts while holding on to their religion. For example, when one of the students was interviewed his shift from a religious worldview to a scientific one concerning a particular issue, he said

> *Abel: At this stage, because I've just started learning about doing this evolution course. I am struggling to make decisions…I am a Christian and so I believe everything goes along with that. But then how evolution fits in. That's something that I am still discovering and learning about. And I am not going to try adapting it to my religion. Another thing I am not going to do is to disregard any evidence of evolution. Also another thing that I struggle with is that there are evolution doesn't necessarily occur... the way that these organisms descended from the common ancestor, I sometimes struggle with that. Also with the Big Bang theory, I don't believe that. I believe that the earth was created and... and didn't just come from nothing and that the order in nature; that was organized by God.*
>
> *Researcher: Have you changed your view about evolution, the one you had before we started? Can you maybe elaborate? What is your opinion now after the course?*
>
> *Abel: Not much difference, really. But the course for me, which I am very grateful for, is that it's made me think about and to read about it instead of just disregarding it, which is quite important. My opinion hasn't changed me much but it has stimulated me to think further.*

6.1.3 Hazardous/Dependent Cognitive Border Crossing

Hazardous/dependent cognitive border crossing occurs when the worldview schema have gained more or less equal supremacy (i.e., none of the schemata is dominant but all are evident) or where the commonsense-intuitive schema is dominant. Only a few networks can be linked, resulting in misconceptions and/or alternative conceptions. Incoming encoded information will find at least a good fit with the existing knowledge. In other words, the thought systems will match partially, resulting in a misfit. There are two types of hazardous cognitive border crossings. The first occurs when students start off with either a scientific or traditional worldview and end up leaning toward the scientific worldview but with a lot of misconceptions. The second type occurs when students are split between the two worldviews but do not come up with a decision on which way to take. This might or might not result in alternative misconceptions. Not all the students in the Fakudze and Holtman (2003) study were clear about their opinions about the selected evolution items, some ended up unsure. These started with a religious worldview, a scientific worldview, or un-

sure and ended up not knowing anything about a particular evolution concept. One student, Benson, responded as follows during an interview:

> *Researcher: Is there any conflict between evolution and the bible?*
>
> *Benson: Because on the one hand evolution talks about how we evolved from this, from this, from that. And on the one thing I was brought up God made us seven days, I don't know, six days. I was brought printed in my mind that we are made by God and we are special and we can't evolve. It's conflicting man. I am actually confused. We've been taught for seventeen years at home about God and now came to university and taught about…*

6.1.4 Impossible Cognitive Border Crossing

Impossible cognitive border crossing occurs when the traditional worldview schema is dominant and none of the networks can be linked because students fail to attach it to the existing information in their LTM. No collateral learning takes place, resulting in the rejection of the incoming information. Students stick to their traditional worldview presupposition regarding that particular concept. This occurs when students retain their traditional worldview even after instruction or when they started unsure of the answer and ended up with a traditional worldview. Such students may or may not have valid scientific conceptions of the issues under discussion. If they do, they only use them to answer examination questions in order to get marks. Some of the students in the Fakudze and Holtman (2003) study held a religious worldview about evolution at both the pre-test and post-test stages of the research. When one of them, Samson, was interviewed about how he coped in class when the lecturer taught about a topic that conflicted with his beliefs, he said:

> *Samson: In my head, firstly, there were one or two or three times or more where I said to myself this is nonsense. This is nonsense, I won't accept that part, this is pure nonsense but because of my respect for my lecturer, I won't tell that to him because I am telling you one thing, I have very much respect for all my lecturers. Then I will say to myself, "O.K. let me just put that aside and just listen to it". Then I listen to it. Where I feel this is nonsense, I put that part aside and I will just listen to you and let you talk out and then I will say, well this is your point but I will still believe that part but I will study this part and at that moment I will say to myself 'O.K. I will study that and that and that even though it is not like this but I will study this'. This is going through my mind. I will study it for my exams but do I accept it, no ways.*

Further investigation and clearer articulation are needed for the cognitive process involved in the various categories of border crossing, contiguity learning, and collateral learning. Certainly further studies are needed to determine this proposition as well as the specific conditions responsible for the process of cognitive border crossing from a traditional to a scientific worldview besides those laid out by the proposed CBCLM. Also, it is apposite to state that the information-processing model depicted in the CBCLM was found to be only an aspect of a more complex mechanism that needs further interrogation.

7. CONCLUSIONS

The use of language is an important aspect of border crossing and its management. In situations where two languages are in use (one is a home language and the other is associated with academic discourse), the languages can be viewed as representative of both sides of the border. While the language of instruction can be used for life world discourse, it would more commonly be associated with academic usage in many of the Southern African contexts described above. Use of language is normally embodied in contexts that carry with them social mores and ways in which language is used. Where the two sides of the border are reinforced by a difference of language and the need for code switching, the gap can appear wider and more difficult to cross.

A promising way forward would be to make positive use of the linguistic tools that Southern African learners have at their disposal through the use of metacognitive strategies, making them aware of the two worlds they straddle. For Gee (1996), learning is primarily a process of gaining metaknowledge, primarily about the differences between the discourse to be acquired (Gee refers to this as a secondary discourse) and the learners' primary discourse (the language learners already have in relation to their home community).

Vygotsky (1978) conceptualised language as a tool for the mediation of meaning between the student and a more capable peer. If appropriately mediated, informed use of different discourses in different languages will provide a wide array of sophisticated tools to enable border crossing. The combinations of language and discourse would include second language discourse as suggested by Rollnick's (2004) model, which allows a form of managed border crossing that may assist transition between the discourses.

This is a paper about enabling the learning of science concepts and hence the interest of authors is in providing access to the study of western science, which asks students to pay the cost of changing their worldview in order to accept that of western science. Fakudze's (2004) model provides insight into existing possibilities for successful border crossing and the language strategies above provide the tools for this to happen. Further studies now need to be undertaken to validate Fakudze's routes and find out whether the use of discourses associated with the various worldviews enables or constrains students in the acquisition of science concepts.

Thus instead of eliminating students' worldviews, science education should start from the students' understanding of natural phenomena and become more aware of the impact of cultural variables (such as traditional beliefs and traditional affiliations) in their teaching efforts and increase the amount of discussion that takes place in the science class. We align ourselves with Gunstone and White (2000) who proposed a coexistence approach where the learners are not made to abandon their cultural background knowledge for conventional science but instead are encouraged to adjoin the two worldviews. Learners should decide for themselves which worldview is appropriate to the situation before them, just as scientists will under certain circumstances apply everyday reasoning to solve problems.

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