This study reports on a project that seeks to enhance educators' understanding of and ability to implement a Science Indigenous Knowledge Systems (IKS) curriculum through using the theoretical framework of argumentation such that learners would grasp the nature of both thought systems. Using an experimental design, this study sought to find out how Grade 10 learners' conceptions of fermentation are affected by a Dialogical Argumentation Instructional Model (DAIM), as opposed to a more traditional teaching approach. The findings were that the DAIM seemed to be more effective in improving learners conceptions of fermentation, and their awareness of science and indigenous knowledge systems.

UNIVERSITY OF CAPE TOWN

Effects of a Dialogical Argumentation Instructional Model on Grade 10 Learners' Conception of Fermentation

Christopher Diwu

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Acknowledgements

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Contents

List of Tables

Abbreviations

ASs	Assessment Standards
C2005	Curriculum 2005
CAT	Contiguity Argumentation Theory
COFQ	Conception of fermentation questionnaire
CU	Conceptual Understanding
DAIM	Argumentation Instructional Model
DoE	Department of Education
FGIQ	Focus group interview question
IK	Indigenous Knowledge
IKS	Indigenous Knowledge Systems
IKSW	IKS world view
KA	Knowledge Application
LoLT	Language of Learning and Teaching
LOs	Learning Outcomes
LTSM	Learning and Teaching Support Materials
NCS	National Curriculum Statement
NOIKS	Nature of Indigenous Knowledge Systems
NOS	Nature of Science
OBE	Outcomes Based Education
PU	Process Understanding
R	Information Recall
RNCS	Revised National Curriculum Statement
SAT	Science Achievement Test
SIKSP	Science and Indigenous Knowledge Systems Project
SSW	School Science World view
SSI	Socio-Scientific Issue
TAP	Toulmin's Argumentation Pattern
WCED	Western Cape Department of Education

Abstract

This study has been motivated by the Science and Indigenous Knowledge Systems Project (SIKSP) at the School of Science and Mathematics Education, University of the Western Cape. The project seeks to enhance educators' understanding of and ability to implement a Science – IKS curriculum (Ogunniyi, 2007) through using the theoretical framework of argumentation such that their learners would grasp the nature of both thought systems.

As a direct response to the above theme, this study sought to find out how Grade 10 learners' conceptions of fermentation are affected by a Dialogical Argumentation Instructional Model (DAIM). Since Science and IKS are premised on two distinct world views, two corresponding theoretical argumentation frameworks have been utilised respectively, that is; Toulmin's (1958) Argumentation Pattern (TAP) and Ogunniyi's (1995) Contiguity Argumentation Theory (CAT).

The study catered for empirical and metaphysical dimensions of science and IKS. The study employed a quasi-experimental design as well as a qualitative research design. Two cohorts of students from a fictitiously named 'Culture Secondary School' have been used in this study. The list of instruments for data collection were as follows: Conceptions of Fermentation (COF) questionnaire which was used to elicit learners' pre- and post-test conceptions of fermentation with special reference to traditional beer or 'umqombothi', an Attitudes to Science (ATS) questionnaire which was used to find out the learners' world views, a Science Achievement Test (SAT) which was used to assess the learners' generalised knowledge of fermentation, a classroom observation schedule as well as a focus group interview schedule to gather additional qualitative data. All the instruments were in English with all technical and difficult terms in both English and isiXhosa (the learners' home language). Both groups were exposed to Science/IKS-based lessons. The only difference between the two groups was that, the experimental group (E group) was exposed to a Dialogical Argumentation Teaching Model (DAIM) and the comparison group (C group) to a traditional teaching approach. The data gathered were both analysed in terms of qualitative and quantitative descriptions.

The main findings of the study revealed that:

- The pre-test scores of the two groups showed that: they were comparable; they did hold to some extent valid conceptions about fermentation; and that they had a relatively positive attitude towards science and to some degree IKS as well.

- At the post-test the E group outperformed the C group in terms of the COF questionnaire and the SAT. The E group subjects showed a greater awareness about, and an understanding of the Nature of Science (NOS) and Nature of IKS (NOIKS) than the C group subjects.

Although the intervention was only for a period of six weeks, the Dialogical Argumentation Model (DAIM) seemed to be effective in improving the E group learners' conceptions of fermentation as well as the improvement of their awareness of NOS/NOIKS than for their counterparts in the C group. The implications of these findings are reported in Chapter 5.

Opsomming

Hierdie stuk navorsing is gemotiveer deur die Science and Indigenous Knowledge Systems-Projek (SIKSP) by die School of Science and Mathematics Education, Universiteit van Wes-Kaapland. Die projek poog om die opvoeder se begrip van en vermoë om 'n Wetenskap – IKS-kurrikulum (Ogunniyi, 2007) te implementer, te verhoog, deur gebruik te maak van 'n teoretiese raamwerk wat leerders die aard van albei kennisstelses sal laat verstaan.

In respons op die bogenoemde tema, het hierdie studie probeer uitvind hoe Graad 10 leerders se begrip van gisting deur 'n Dialogiese Argumentasie Instruksie Model (DAIM) geraak word. Aangesien die Wetenskap en IKS op twee verskillende wêreldbeskouings rus, is gebruik gemaak van twee ooreenstemmende teoretiese raamwerke, naamlik Toulmin se (1958) argumentasie-patroon, en Ogunniyi se aangrensende argumentasie-teorie (1995).

Die navorsing het rekening gehou met die empiriese sowel as die metafisiese aspekte van die wetenskap en van IKS. Daar is van 'n kwansuis-eksperimentele ontwerp sowel as 'n kwalitatiewe navorsingsontwerp gebruik gemaak. Twee kohorte leerders van die 'Culture Sekondêre Skool' ('n skuilnaam) was by die studie betrokke. Die instrumente vir data-inwinning het die volgende ingesluit: 'n Voorstellings van Gissing vraeboog wat benut is om die leerders se voor- en post-toets opvattings van gissing vas te stel, met spesifieke verwysing na tradisionele bier of 'umqombothi'; 'n Houdings jeens die Wetenskap-vraelys wat benut is om die leerders se wêreldbeskouing vas te stel; 'n Wetenskap Prestasie-Toets wat benut is om die leerders se algemene kennis van gissing te bepaal; 'n klaskamer observasie-skedule sowel as 'n fokusgroeponderhoud-skedule om bykomstige inligting te vers-

amel. Al die instrumente was in Engels, die onderrigtaal, terwyl tegniese en moeilike terme in beide Engels sowel as in isiXhosa (die leerders se huistaal) beskikbaar was. Albei groepe is aan die Wetenskap/IKS-gebaseerde lesse blootgestel. Die enigste verskil tussen die tween groepe was dat die eksperimentele groep (die E-groep) blootgestel is aan 'n dialogiese argumentasie onderrig-model, terwyl die vergelykingsgroep 'n tradisionele benadering ervaar het. Die inligting is in kwalitatiewe sowel as kwantitatiewe terme ontleed.

Die hoofbevindinge van dié stuk navorsing is soos volg:

- Die voor-toets punte van die twee groepe toon dat hulle vergelykbaar was, dat hulle tot 'n sekere mate geldige voorstellings oor gissing gehad het, en dat hulle 'n taamlik positiewe houding jeens die wetenskep en tot 'n sekere mate ook tot IKS ingeneem het.
- Tydens die post-toets het die E-groep beter gevaar as die C-groep in terme van die Voorstellings van Gissing vraeboog en die Wetenskap Prestasie-Toets. Die E-groep leerders was ook meer bewus van, en het groter begrip getoon vir, die Aard van die Wetenskap en die Aard van IKS.

Terwyl die intervensie slegs ses weke geduur het, het die Dialogiese Argumentasie Instruksie Model geblyk om meer doeltreffend te wees mbt die verbetering van die E-groep leerders se voorstellings van gissing sowel as die groter gewaarwording van AW/AIKS, as vir hulle eweknieë in die C-groep. Oor die implikasies van hierdie bevindinge word in Hoofstuk 5 berig gelewer.

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Oluphando luye lwaphenjelwa yiprojekti equka izifundo zeNzululwazi kwakunye nezo zeNkqubo yoLwazi lwezeMveli (Indigenous Knowledge Systems) ekuthiwa yi-SIKSP kwiSikolo seziFundo ze'Nzululwazi' kwakunye neMathematika kwiYunivesithi yaseNtshonakoloni. Iinjongo zaleprojekti kukuphuhlisa ulwazi nezakhono zabafundisi-ntsapho ekuhlomeleni uLwazi lwezeMvelo kwiziFundo ze'Nzululwazi' (Ogunniyi, 2007) ngokuthi basebenzise ubuchule bokufundisa ekuthiwa yingxoxo-mpikiswano (argumentation) apho abafundi bathi bafumane amava okwazi ukwahlula nokusebenzisa ulwazi lweze'Nzululwazi' kwanolo lwezeMveli, ngaloo ndlela befumana ulwazi lweziseko-lulwazi (worldview) nemo yolwazi (knowledge) ngalunye.

Njengempendulo kumceli-mngeni omenyelelwe loluphulo lungentla, oluphando belujongene nokufumanisa ukuba iguquguquka njani ingqiqo yabafundi bebanga le-10 malunga nolwazi lwezididiyelo xa bathe baphantsi kwempembelelo lwezifundo eziqhutywe ngendlela yengxoxompikiswano, i-*Dialogical Argumentation Instructional Model* (DAIM). Njengoko eze'Nzululwazi' zisebenza phantsi kweziseko-lwazi (worldview) ezahlukahlukeneyo nezo zolwazi lwezeMveli, kuye kwafuneka kusetyenziswa imigaqo-lwazi (Theoretical frameworks) lweengxoxo-mpikiswano (argumentation) emibini eyahlukeneyo ngokulandelelanayo, *i-Toulmin's (1958) Argumentation Pattern* (TAP) kwakunye nesiseko-lwazi (Theory) sika *Ogunniyi's (1995) Contiguity Argumentation Theory* (CAT).

Oluphando luye lwalungeleliselwa iinkalo zeziseko-lwazi (worldviews) zophando-zathuzo (empirical) ngokweze'Nzululwazi' kwakunye nezo zophando-nkolelo (metaphysical) ngokwenkqubo yoLwazi lwezeMveli. Oluphando lusebenzise uyilo-luphando (research design) i-*quasi-experimental* kwakunye noyilo-luphando lohlalutyo-zivakalisi (qualitative). Oluphando lusebenzise amaqela amabini ophando asuka kwisikolo i-'Culture Secondary School' (igama lamaxoki-xoki). Nalu uluhlu lwezixhobo zokuqokelela uLwazi: i-*Conceptions of Fermentation (COF) questionnaire* eye yasetyenziselwa ukuncina ulwazi lwabafundi malunga nezididiyelo (fermentation) phambi nangasemveni kokuba benikwe izifundo ezingxile kulwazi lokudidiyelwa komqombothi, izimvo malunga neze'Nzululwazi' (Attitude to 'Science') ebezisetyenziselwe ukuncina izimvo zabafundi malunga neziseko-lulwazi, *i-Science Achievement Test* (SAT) ebisetyenziselwe ukuncila ulwazi-jikelele malunga nodidiyelo zididiyelo, isicwangciso soqwalaselo-zifundo eklasini (classroom observation schedule) kwakunye nodliwano-ndlebe (interview) olujolise kumaqela (focus group) olunjongo yalo ibikukucholachola inkcukacha ezifihlakeleyo nezo izixhobo zovavanyo zingabanganako ukuzichola. Zonke ezizixhobo bezibhalwe ngesiNgesi apho izigama ezinobunzululwazi (Technical) bezibhalwe ngesiNgesi kwakunye nesiXhosa (ulwimi lwabafundi, ekhaya). Omabini amaqela aye afundiswa izifundo ezifanayo ezisekelwe kweze'Nzululwazi' kwakunye nezolwazi lwe- *IKS.* Umahluko obukhona kulamaqela mabini ibikukuba eli le-*Experimental* (E group) liye lafundiswa ngendlela esebenzisa inkqubo yengxoxo-mpikiswano i-*DAIM* laze eliqela lithelekiswa nalo *i-Comparison group* (C group) lafundiswa ngendlela yesiqhelo ekuthiwa yi-*traditional teaching approach.* ULwazi oluye lwacholacholwa luye lwahlalutya ngendlela yohlalutyo-ngamanani (quantitative) nangeyo hlalutyo-zivakalisi (qualitative). Iziphumo ezingundoqo koluphando zibonise ukuba:

- Amaqaku eziphumo zophando phambi kwezifundo abonise: ukuba lamaqela mabini ebelingana ngokolwazi namanqaku; bekwabonakalise ukuba nolwazi oluphangaleleyo malunga nokusilwa kwezididiyelo (fermentation); kwaye babonakalise umdla omkhulu nolwazi malunga nezeNzululwazi nenkqubo yoLwazi lwezeMveli (IKS).
- Emveni kwezifundo iqela *le-Experimental* (E group) liye lalibhexesha kanobomi ngamanqaku elo *le-Comparison group* (C group) ngokweeemvavanyo zengqiqo kwezosilo zididiyelo (COF questionnaires) kwakunye nezo zolwazi-jikelele (SAT). Iqela le *E group* libonise ukuba nolwazi nezimvo eziphangaleleyo malunga nemo-lwazi (nature) ngeze'Nzululwazi' ('Science') ekuthiwa yi-*NOS* kwakunye nemo-lwazi nge-*IKS* ekuthiwa yi-*NOIKS* kuneqela le-*C group.*

Nangona izifundo zophando zathabatha iiveki ezi-6 kuphela, indlela yokufundisa i-Dialogical Argumentation yabonakalisa impumelelo ekuphuculeni ulwazi nengqiqo yeqela le-Experimental (iqela lovavanyo lwendlela yokufundisa ekuthiwa yi-DAIM) ngokubhekiselele kulwazi ngezifundo ze-fermentation (izididiyelo) nasekuphangaleliseni ulwazi lwabo ngokubhekiselele kwi-NOS/NOIKS xa bebethelekiswa neqela le-comparison (iqela lothelekiso). Iziphumo zoluphando zibhengezwe kwisahluko se-5.

1. Introduction to the study

Key terms

1. Dialogical Argumentation Instructional Model (DAIM)
2. Grade 10 learners
3. Conceptions of fermentation
4. Curriculum 2005 (C2005)
5. Science – IKS curriculum
6. Border Crossing
7. Socio-cultural Constructivism
8. Toulmin's Argumentation Pattern (TAP)
9. Contiguity Argumentation Theory (CAT)
10. Pre-test/post-test quasi experimental design

1.1 Introduction

In 1997 the South African government introduced a new curriculum called Curriculum 2005 (C2005) to indicate the year it would have been implemented at all levels of education. The introduction of C2005 has been justified on account of the socio-political history of South Africa (Ogunniyi, 2007: 963). Consonant with the above view, and prior to 1994, the South African education system was divided along racial, ethnic and demographic boundaries, with 19 separate education departments, schools and residential locations (Enderstein & Spargo, 1998). After the 1994 democratic elections, the South African government, envisaging a multicultural classroom, had to reflect and accommodate all learners' backgrounds. Since C2005 was enacted, a string of issues pertaining to its implementation has surfaced. Issues such as teachers' opposition to it, untrained teachers, the high level of the language used in the curriculum document and, most importantly, the question of interfacing indigenous knowledge system (IKS) with school science. These problems will be elaborated upon later. In an attempt to address the above problem, this study sought to explore one of the most important aspects of science, i.e. argumentation. As can be seen within C2005 itself and its revised versions, the Revised National Curriculum Statement (RNCS – Grades R–9) as well as the National Curriculum Statement (NCS – Grades 10–12), argumentation, both as a philosophical premise of science and as an instructional tool has been underrated. However, both documents encourage classroom discourse and group activities. This study investigated the effectiveness, or otherwise, of a Dialogical Argumentation Instructional Model on Grade 10 learners' conceptions of fermentation. Many home-based and industrial-based foods and beverages use the process of fermentation. Fermentation is also a very important process in medical and biotechnological products and hence its topicality as a concept worthy of closer consideration.

This thesis is divided into five chapters. Chapters 1, 2, 3, 4 and 5 constitute the introduction to the study, the literature review, the methodology, the data analysis with discussions and the conclusions respectively. Chapter 1 is divided into an introduction; the background (which looks at the science curriculum and its integration with IKS); the problem statement highlighting the issues relating to the implementation of a Science-IKS curriculum; the rationale for proposing an argumentation instructional strategy, the conceptual underpinnings for an argumentation method of teaching and learning; the purpose of the study which is to present in a refined and crisp manner the research questions and; finally, the significance of this study. Chapter 2 focuses on the theoretical issues and literature review about science and IKS epistemological underpinnings; literature review on the interfacing of IKS with school science, theoretical issues about fermentation as a topic common to both science and IKS; literature review regarding forms of 'border crossing' from an IKS into a school science world view and; how argumentation facilitated such kinds of border crossing. Finally, practical consideration of what theoretical framework for guiding this study will be explicated and elaborated upon. Chapter 3 provides the setting of the research site, and the sample selection procedure. Here, details of the research paradigm including the research design, research instruments and how they were validated and detailed for ease of reference. The chapter concludes with data collection, analysis and ethical considerations. Chapter 4 deals with the analysis and discussions of the data and concludes with the summary of the findings. Chapter 5 presents the conclusions, implications, limitations and recommendations of the study.

1.2 Background

As has been highlighted in the introduction, the implementation of C2005 has given rise to a lot of controversy. In an attempt to resolve this controversy, the Department of Education, in 2002, introduced two other policy documents as a revision for C2005, the Revised National Curriculum Statement (RNCS – Grades R– 9) and the National Curriculum Statement (NCS) (DoE, 2002). These documents focused and outlined certain Learning Outcomes (LOs) and Assessment Standards (ASs). Learning Outcomes 3 and 4 emphasise the teaching of the Nature of Science (NOS) and the integration of Indigenous Knowledge Systems (IKS) with school science. In support of the above, the Department of Education made the following statement in the National Curriculum Statement:

> Now people recognise the wide diversity of knowledge systems through which people make sense of and attach meaning to the world in which they live. Indigenous knowledge systems in the South African context refers to a body of knowledge embedded in African philosophical thinking and social practices that have evolved over thousands of years. The National Curriculum Statement Grades 10–12 (General) has infused indigenous knowledge systems into the Subject statements (Le Grange, 2004: 205).

Ogunniyi (2007: 963) cites two reasons for introducing IKS into school science as follows:

> IKS reflects the wisdom about the environment developed over centuries by the inhabitants of South Africa, and much of this valuable wisdom believed to have been lost in the past 300 years of colonization now needs to be rediscovered and utilized to improve the quality of life of all South Africans.

As an affirmation of the need to rediscover this lost knowledge and wisdom, Corsiglia & Snively (cited in Ogunniyi, 2007) have also argued that, 'Indigenous science offers knowledge that western modern science has not yet learned to produce, hence the need for its recovery' (p. 964). It is clear from this that interfacing of school science with IKS has been introduced with good intentions, such as the rediscovery and recovery of lost IKS knowledge. But, whilst there might be a desire to do so, it is also important to note that IKS and 'western science' view natural phenomena from two distinctively different perspectives (Ogunniyi, 2008). He argues that school science views natural phenomena from a mechanistic view and uses empirical methods in explaining its observations and that it is only amenable to deductive-induction reasoning, whilst IKS views natural phenomena from an anthropomorphic world view. In other words, it uses both logical and non-logical forms of argument to explain and interpret natural phenomena (Ogunniyi, 2007, 2008 and 2009). In view of this it can be expected that the teaching of concepts, like fermentation, from only the scientific viewpoint, is likely to create cognitive confusion among learners from indigenous communities who hold different viewpoints (Aikenhead, 1996; Aikenhead & Jegede, 1999; Jegede, 1996).

In order for effective integration of the two world view suppositions to take place, a new teaching approach has to be pursued, one that will establish the two world views on equal footing and accord them the same status (Onwu & Mosimege, 2004). This approach should create an enabling environment that will, whilst valuing the learners' prior knowledge, also allow them to externalise their views regarding their existing knowledge and the new knowledge presented in a science classroom (Erduran, Simon & Osborne, 2004; Ogunniyi, 2007a & b). Regarding valuing learners' prior knowledge, Campbell & Lubben (2000) contend that, 'contextualization improves access to knowledge and thus provides equity to disadvantaged groups' (Campbell & Lubben, 2000: 239). In his book *An Argumentation-based Package on the nature of science and indigenous knowledge systems*, Ogunniyi argues for two perspectives in favour of argumentation and dialogical practices in the classroom, i.e.

> From socio-cultural and psychological perspectives interactive classroom arguments and dialogues can help teachers and students to clear their doubts, upgrade current knowledge, acquire new attitudes and reasoning skills, gain new insights, make informed decisions and even to change their perspectives ...
>
> From a history of science perspective science has tended to progress more by arguments, dialogues, revolutionary ideas than by consensus. (Ogunniyi, 2008: 11)

From the above citation it can be argued that argumentation and dialogical teaching and learning practices can be used to evaluate the processes of 'border crossing between distinct world views' (Ogunniyi, 2008). According to him border crossing deals with the struggles learners engage in as they attempt to reconcile their world views with school science (p. 1).

A curriculum that seeks to integrate two different world views (like school science and IKS) requires teaching and learning strategies that will

encourage learners and provide them with thinking and reflection so that they can recognise the merits and demerits of each world view, and hence be in a better position to know when one thought system is appropriate.

1.3 Problem statement

In this section I would like to elaborate on what I think is the real underlying problem of C2005. In the section above I have highlighted that, although the integration of IKS with school science had probably been premised on good intention, the problems surrounding its implementation seem to supersede the good intentions envisaged in the policy documents. C2005 critics cited a whole range of reasons for rejecting it. Others complained about issues of socio-economic imbalances that need to be addressed or else it should be abandoned.

In his preamble to his book, *An Argumentation-based Package on the nature of science and indigenous knowledge systems,* Ogunniyi asks an intriguing question regarding the near impossible ambition of the RNCS and NCS documents published by the Department of Education (2002) with respect to the integration of IKS into school science as follows:

> How can educators help learners to make cognitive shifts between their personal belief (underpinned by metaphysical and anthropomorphic assumptions) and the scientific belief underpinned by a mechanistic world view. (Ogunniyi, 2004: 291)

In attempting to summarise C2005's challenges, Ogunniyi (2007: 964) lists four reasons why teachers in South Africa opposed the new curriculum. The reasons are that:

- Teachers were schooled in western science and hence were more familiar with that world view than that of IKS.
- The new curriculum demanded new instructional approaches and goals in terms of contextualization and indigenisation rather than the old status quo of the mastery of scientific information for examination purposes which they were used to.
- The top down approach in which the curriculum had been implemented seemed to underrate the teachers' role in curriculum planning and implementation.
- The lack of clarity on how a Science-IKS curriculum could be implemented.

The reason for highlighting problematic issues surrounding the implementation of C2005 is supported by the November 2009 Ministerial Final report which admitted that the problem was implementation and tried to identify the issues and the nature of the challenges involved. For example, issues such as advocacy, infrastructure, learning and teaching materials (DoE, 2009), teacher training in as far as the Nature of Science (NOS) and Nature of Indigenous Knowledge Systems (NOIKS) are concerned; and the need to find a plausible connection (Ogunniyi & Ogawa, 2008).

Though the reasons explicated for and against C2005 may be an issue, the issue of bringing together distinctively different and drastically different teaching and learning approaches is perhaps far more challenging. The lack of clear-cut implementation strategies in terms of identifying appropriate teaching and learning materials consonant with the goal of the curriculum about rediscovery and the recovery of 'lost knowledge' and ensuring that the two world views are made compatible with each other was certainly a matter of great concern from its inception (Fleer, 1999: 121).

1.4 Rationale for the study

1.4.1 Introduction

Much of the problems deliberated in the section above reveals, in one sense, that the implementation of any curriculum innovation (especially a Science-IKS one), places an enormous responsibility on the teachers (or educators, as they are called in South Africa). Secondly, if educators have a poor understanding of the nature of science and of IKS in terms of understanding their theoretical underpinnings, similarities and limitations, then it is almost impossible to expect them to succeed in implementing such a curriculum. The Minister of Basic Education appointed a panel of experts to investigate the nature of challenges and problems experienced in the implementation of the National Curriculum Statement (NCS) and to develop a set of recommendations designed to improve the implementation of the new curriculum. Whilst the report covered a whole range of issues regarding the implementation of the NCS, its recommendations were silent on the issue of one of its learning outcomes, namely Learning Outcome 3, which calls for the inclusion and integration of IKS in the school curriculum and the nature of science (NOS).

Since, as indicated earlier, IKS and western science are underpinned by different epistemological beliefs, views and values, one would have expected that one of the recommendations regarding the implementation of the NCS would focus on how and what teaching-learning and assessment strategies would enhance smooth implementation of a Science-IKS curriculum. For instance, one would like to know what training teachers need to interface and infuse IKS with school science. Furthermore, none of the four reasons stipulated for the opposition to C2005 by teachers has been explicitly addressed within the five year plan for improving the implementation of the NCS. There are other issues that could be raised. For example, the report did not touch on the issue of the examination-driven South African education system which Ogunniyi (2006: 118) regards as a major source of concern. However, this is not the focus of this study. In addition to the envisaged primary and secondary purposes of the study, some other pieces of information regarding the relationship between the language used in science and the language of IKS and how these enhance rather than hinder learners from developing a robust world view have been explored. But developing such a world view implies that an enabling environment is provided to discuss, argue and externalise one's world view. As the extant literature has consistently shown, dialogues and arguments engender such an enabling environment (e.g. Erduran et al., 2004; Ogunniyi, 2007a).

1.4.2 Argumentation

The National Curriculum Statement document envisages learners that should not only be able to master content knowledge in science, but that these learners should be able to develop critical thinking and reasoning skills. They should be able to evaluate scientific and technological products and their processes with regard to safety on humans and the environment. In order to achieve these goals, teaching, learning and assessment strategies that enhance the awareness of the nature of science and IKS should be built into classroom practice. According to Ogunniyi (2007a), learning involves internal arguments within the learner as he/she processes the claims proposed by the teacher or learning material. Unless this internal self-argumentation takes place, meaningful learning is impossible and in that case learning becomes a 'one-way street' leading to a cul-de-sac. Turning around in a one-way street is forbidden and has dire consequences of a head-on collision with on-coming traffic. The Learning Outcomes 3 of science in the NCS document stipulates that, whilst investigative enquiry and scientific knowledge construction are important, the nature of science and its impact on society and the environment should be queried. This study is informed by the quest for implementation of such aspirations. In conclusion, Erduran sums it up in this way:

> Failure to emphasize and foreground the distinctive hallmark of science is ultimately self-defeating leaving students with beliefs they are unable to justify to others (Erduran, 2006: 14).

This 'hallmark of science' as elaborated, is argumentation. As a conclusion, Patronis et al. (1999), sum up the need for an argumentation approach this way:

> However, the nature and quality of the students' arguments in the process of defending their own proposals or criticizing the proposals of the others has not yet been systematically examined. Argumentation is an important part of decision-making, and it is in this area that scientific and technological knowledge comes into question (p. 745).

1.5 Purpose of the study

The purpose of this study was to determine the effects of a Dialogical Argumentation Instructional Model (DAIM) on Grade 10 learners' conceptions of fermentation as exemplified both in school science and Indigenous Knowledge Systems (IKS). The study also tried to elicit information regarding learners' IK using a largely bilingually structured pre-test and post-test questionnaire.

The fermentation process has been used from one generation to another for various food and beverage products. School science covers a number of fermentation based topics across natural sciences as well as in technology. It was also believed that a fermentation topic would perfectly suit a study that sought to investigate the effectiveness or otherwise of a teaching and learning strategy on a Science and IKS-based curriculum. More on fermentation as a theme will be elaborated upon in Chapter 2.

1.6 Research questions

- What Scientific/IKS conceptions of fermentation do Grade 10 learners hold and do these conceptions relate to their ages, gender and/ or rural/urban up-bringing?
- What effect does a DAIM have on Grade 10 learners' conception and understanding of fermentation, learners' attitude to science and IKS?
- Will the awareness and understanding of the NOS and NOIKS of Grade 10 learners' exposed to a DAIM be enhanced more than those not so exposed? Secondary to this, is there any correlation between learners' socio-cultural language use and the terminology used in science?

1.7 Significance of the study

It was hoped that results from this study would help in:

1. Strengthening the position that IKS is a reservoir of knowledge that the learners could use as a veritable platform to develop a robust world view not only about what they learn from their communities but also what they learn in school science.
2. Contributing to the improvement or enhancement of current scientific knowledge, values and attitudes about the world we are living in.
3. Inspiring learners to value science knowledge embedded within their indigenous knowledge systems as well as increasing their awareness of different world views about natural phenomena.
4. Reducing the negative perceptions that are associated with the integration of IKS with the science curriculum.
5. Strengthening the position that, an argumentation instructional model is an effective tool for developing learners' and teachers' understanding of the nature of science and IKS.
6. Identifying links between the learners' socio-cultural language and the language of science.
7. Creating awareness among curriculum developers that the implementation of a Science-IKS curriculum, free of epistemological discrimination would go a long way in affirming learners' diversity with respect to developing their sense of identity as well as their diverse socio-cultural backgrounds.
8. Providing additional data that researchers, educators, curriculum planners and other stakeholders could find useful and informative in reaching informed decisions regarding the new science curriculum.

1.8 Operational definitions

Assessment – A means of evaluating students' understanding or knowledge using a form of achievement test, questionnaires or interviewing process.

Conception – A mental idea or one's perception about the nature of a given subject matter.

Fermentation – A chemical reaction that is activated by the aid of microorganisms like yeast, fungus, moulds and bacteria to produce new products or chemicals.

Indigenous Knowledge Systems (IKS) – A system of thought peculiar to people of a local geographic location or socio-cultural environment (Ogunniyi, 2008: 6).

Language in Education Policy (LiEP) – A government policy within South Africa's education system which was enacted to provide a framework for the promotion and protection of all languages used in the country (DoE, 1996).

Language of Instruction – The language in which teaching and the learning materials are presented in the classroom.

Language of learning and teaching (LoLT) – The official language used in learning instruction and in which assessment of outcomes are carried out rather than referring only to English and Afrikaans as was the case during the apartheid era (DoE, 1996).

Nature of Indigenous Knowledge Systems (NOIKS) – All explicit or implicit underlying assumptions underpinning the epistemologies of indigenous knowledge systems.

Nature of Science (NOS) – All explicit or implicit underlying assumptions underpinning the epistemology of school science.

Revised National Curriculum Statement – A policy document setting guidelines for curriculum implementation in the General Education and Training band of the education system in South Africa.

Science/IKS curriculum – This term refers to the new South African school science curriculum especially Outcome 3 which calls on teachers to integrate IKS with school science school science.

Sociocultural Critical Constructivism – Constructivism that takes cognisance of learners' socio-cultural environment.

World view – To Kearney (cited by Ogunniyi et al., 1995) 'A world is a culturally organised macro-thought: those dynamically interrelated assumptions of a people that determine much of their behaviour and decision making, as well as organising much of their body of symbolic creations … and ethno-philosophy in general' (p. 818).

2. Literature Review

2.1 Introduction

As has been outlined in Chapter 1, the main issue surrounding the implementation of C2005 has been the inclusion of IKS into the main school science curriculum. Some of the rationales cited for the inclusion of IKS were:

- There is 'lost knowledge' within IKS that needs to be rediscovered and recovered (Le Grange, 2004; Ogunniyi, 2007).
- 'People tend to use different ways of thinking for different situations, and even scientists in their daily lives may have religious frameworks or other ways of giving value to life and making choices …' (DoE, 2002: 12) and that:

  > ... One can assume that learners in Natural Sciences Learning Area think in terms of more than one world-view. Several times a week they cross from the culture of home, over the border into the culture of science, and then back again (DoE, 2002: 11–2; Ogunniyi, 2004: 291).

As can be argued, C2005 was premised on good notions of socio-cultural learning and teaching experience where the focus was on learners constructing their own knowledge rather than being seen as computer machines reflective of the adage, 'Garbage in, garbage out'. The latter suggests that learners were expected to regurgitate information. However, to correct this anomaly the new curriculum expects educators to be active facilitators of learning within the classroom rather than as transmitters of knowledge. However, the new curriculum has not stated explicitly how that facilitation should occur. Interpretation and delivery of the curriculum was left solely on the shoulders of the educators. The Department of Education expected that learning outcomes as depicted (C2005) would somehow be magically achieved. However, as Ogunniyi (2008) states, Learning Outcome 3 and the other two outcomes demand a radically different instructional strategy from the old fact – oriented curriculum. For many educators, the shift was from an educator-centred approach to the polar opposite of a learner-centred approach. Learners were supposed to work in groups and discuss something that they did not understand or have knowledge of, whilst the educator was not sure what to do while the learners were discussing in groups. The above observations suggest in one way or another, that the implementation of curriculum 2005 neglected issues relating to the implications regarding the epistemic foundations of both science and IKS for classroom practice. It also underrated the necessity to train educators to implement such a radically different curriculum.

In accordance with the above observations, this study is situated within a socio-constructivist learning paradigm. Since the time the constructivist fathers such as Piaget and Vygotsky paved a new way of viewing teaching and learning for classroom practice, the emphasis on the old teaching practice of 'chalk and talk' had changed towards a learner-centred teaching and learning approach. Stears et al. (2003) has put it this way:

> While an individual's knowledge is personally constructed, the constructed knowledge is socially mediated as a result of cultural experiences, personal history, interactions with others in that culture, and the collective experiences of the group. This view of learning places importance on the context in which learning occurs (p. 110).

In my teaching experience, teaching and learning strategies that teachers used were generally influenced by what the text books dictated to them. The text books presented one view of science and moreover were not amenable to discursive classroom practices since time and completion of the syllabus have always been the main issue. In contrast to the realities as highlighted above, learning and teaching that is socially mediated and that encourages different world views has not been practised or at least encouraged for classroom practice. In part one of this section, I would like to tease out the issue of interfacing IKS with school science (i.e. epistemic beliefs underpinning the two world view presuppositions), looking at, the concept of fermentation from both world views, the concept of border crossing and how individual learners are able to adapt to their new school science experiences.

2.1.1 Learners' socio-cultural background

In order for effective learning to take place it is argued that the learners' preconceived knowledge should be taken into account. Amongst many resources the learner brings into the classroom is a socio-cultural background

incorporating IKS knowledge as primary resources (Campbell and Lubben, 2000). According to Chiappetta et al. (1998: 51), 'culturally diverse students develop meaningful science understandings when they see their culture facilitating learning rather than seen as an impediment to it.' The investigation of learners' conceptions of fermentation, as exemplified in both school science and IKS, is an attempt to affirm the above argument. The means of communicating the background knowledge which the learner brings into the classroom is a 'background language', which is the learner's first or home language (Sutherland & Dennick, 2002: 4).

According to Rollnick and Fakudze:

> The knowledge systems of indigenous communities 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 world view (Fakudze & Rollnick, 2008: 3).

As explicated by Fakudze & Rollnick (2008), African languages explain natural phenomena using different epistemological beliefs. This can lead to a lot of confusion for an African learner who has to try and make meaning of what school science is saying, since direct translation from an African language to English might not give a precise meaning. It is difficult to explicate IKS epistemology without referring to the language within which it thrives. This is largely true for educating African learners. Therefore, for the purpose of clarity I will address the language issue in the context of learners' socio-cultural IKS environment. My thesis is that IKS is embedded in its language and vice versa. Moje et al. in Anderson (2007) argue that, in a multicultural classroom, several discourses usually interface, resulting in learners' conceptual conflict and conflict among multiple discourses where each discourse has its own community of practice, all intersecting in the same classroom:

> … The discourses of classroom instruction are informed by what teachers and students believe about the nature of knowledge in the discipline … Similarly, the ways that students take up classroom or disciplinary discourses are shaped by the social or everyday discourses they bring to the classroom (Anderson, 2007: 15).

In the South African socio-political history English and Afrikaans (based on western linguistic roots) have been the major languages of instruction, business and policy in general. All the indigenous languages were, so to speak, relegated to the background. The consequence has been for learners from indigenous communities to learn most of the school subjects (including science) in a second or third language. The subjects of this study are mostly isiXhosa speakers who must learn science through English as a medium of instruction. The learners are exposed to the topic of fermentation processes and are able to communicate their knowledge using isiXhosa, but struggle to demonstrate the same understanding in English because of their limited understanding of English, as well as the differences in the epistemic authorities of the two competing world views. The exemplification of IKS is as a result of the recent political emancipation of South Africa, the demands of self actualization, the restoration of bastardised indigenous cultures and the socio-constructivist learning theories which have given prominence to the recognition of prior learning in the process of teaching and learning. Using this concept as an illustration, learners also struggle in trying to map their conceptual understanding of fermentation onto those that are offered by the school science syllabus, because often there is a mismatch between the concepts they have and those in the corresponding English texts. For an example, school science speaks of yeast as the organism that secrets the enzyme zymase, whilst in the corresponding isiXhosa culture, learners have an understanding of 'inkoduso' for 'malt' or 'iimithombo' for 'germinated seeds' which have the same effect as yeast. Literally, 'inkoduso' means 'home-coming' for the beer brewed for home-coming boys from the initiation school and 'iimithombo' literally means, 'beginnings' referring to the beginning of a life of adulthood and manhood to the home-coming boys from the initiation school. Without the linguistic etymology of words or concepts, it becomes almost impossible for learners from diverse backgrounds to access school science concepts (Rampal, 2005). For instance, to find a corresponding word for yeast in isiXhosa is almost impossible and hence the assumption by some people, that African languages cannot be used in teaching science since they lack vocabulary or relevant terminology (e.g. see Young, 1979).

Sometimes, the concepts used in science do not lend themselves easily to a second language which is the medium of instruction, but rather to the 'language of science' – a 'third language', in the case of African learners. Kearsey and Turner (1999) also claim that western science has a language

of its own. Substantively, this is the language that science teaching and learning is all about. As cited in Kinneavy (1971) the language of science is a 'language of doing, of acting, a language of explanation, speculation and implementation rather than description' (Kearsey and Turner, 1999: 1038). Learners from the isiXhosa culture know what materials to use and how beers are brewed, but lack the descriptive part of the process from a microscopic view which is largely based on 'western' science explanations. As has already been argued by Chiappetta et al. (1998) that learners' culture or background should be used to facilitate learning and not be seen as an impediment. If there is no space for dialogue where the learner is able to externalise his or her views on any given subject, then the learner is left with no choice but to 'sink or swim' through a process of rote learning.

2.2 Theoretical considerations

2.2.1 A science and Indigenous Knowledge Systems Curriculum

As deliberated above, a Science-IKS curriculum is premised on the view that learners come to school with diverse backgrounds and hence are predisposed to different knowledge systems which can be useful in facilitating learning. The sense in which this facilitation is viewed should go beyond the notions of the zone of proximal development put forward by Vygotsky (1978). If viewed in that sense, it would encourage the notion that IKS is subordinate to school science. This would underrate IKS, hence rendering it as an inferior knowledge.

Contrary to the subordinate-superordinate viewpoint about IKS and Science, the Curriculum Corporation (1994) is cited by Fleer (1999) to assert that:

> Scientific knowledge has been expanded by cumulative efforts of generations of scientists from all over the world. It has been enriched by the pooling of understanding from different cultures – western, eastern and indigenous cultures including those of Aboriginal peoples and Torres Strait Islands – and has become a truly international activity (p. 128).

However, Fleer raises a concern that there seems to be an implicit assumption, namely, that all other knowledge systems had come to support the one world view which is 'Western science'.

Fermentation processes as known from an IK perspective do not only provide prior knowledge as a stepping stone for learners to understand school science, but also provides the same school science knowledge in a contextualised manner. The argument here is that there is no opposition between school science and IKS. The two world views are just underpinned by different epistemic authorities and hence both systems of thought strive for objectivity and universal application (Sithole, 2004). Whilst IKS can facilitate transition and enhancement of science, it is sufficiently a valid knowledge system. According to Sithole (2004), science and IKS should not be viewed as opposites, hence the allusion to Science versus IKS as a conceptual accident (i.e. something that should not have happened or that which should not continue in practice). Sithole argues further that there is no Western science or African science, but that 'all knowledge has indigenous origins' (Sithole, 2004: 39; Fleer, 1999). In this regard, we can talk of science and indigenous knowledge systems as well as traditional beer and commercial beer as consequences of a conceptual accident. In reality the occurrence of natural phenomena is blind or immune to that accident referred to by Sithole. If that is the case, then the so-called 'accident' was inevitable, considering underpinning different world view presuppositions supporting these distinct outcomes. For instance, cultured milk as understood from an IKS perspective is the same product as taught in school science. The natural process of fermentation will give us the same product, irrespective of how we perceive natural phenomena. Similarly, traditional beer contains the same substance, alcohol, which industrial beer contains.

Science anatomises the ingredients of the content of the substances in the fermentation process by identifying the active ingredients as well as seemingly non-active ingredients. IKS on the other hand looks at ingredients in a holistic manner. This implies for instance, that the consumption of traditional beer with most of its 'impurities' as would be otherwise be viewed, probably has other benefits which scientists might be overlooking. For instance, the seemingly inactive ingredients do form part of the chemical context which might be beneficial either by providing a healthy environment for survival of the yeast or for the health of humans consuming the product but which are yet to be discovered by science. Commenting on discovery of the thoron – an element which emits radio-active gas, the renowned physicist, Blackett, admonished that every scientist should 'remember … and not fail to keep his eyes open for the possibility that an irritating failure of his apparatus to give consistent results may once or twice in a lifetime conceal an important discovery' (Cline, 1965: 21). Of course, there are copious examples in the history of science where discarded ideas or substances have turned out to become useful later on. But interesting as this issue is, it is not the focus of this study.

The focus of a Science-IKS curriculum is to see to it that learners do not see their forefathers' 'old' ways of brewing beer as outdated, but rather to learn the essentials of the equivalent knowledge as depicted in school science. The health issues relating to the processes used for brewing beer in IKS is of relevance when learning about the scientific process of brewing beer. The health issues are a common variable in any production practice. The infusion of IKS into the classroom science neutralises the hegemony of western science as the only knowledge and at the same time recognising IKS as scientific knowledge in its own right. Scientific knowledge in this sense refers to knowledge derived from inquiries into natural phenomena with the purpose of solving practical problems to gain control of natural processes.

Sithole (2004) argues that, science is not unique and that not all of the so called western science is scientific and further questioned whether or not some of it was simply the values of 'Western Indigenous Knowledge' (p. 38). He further criticises Fakuyama and quotes him as asserting that all of western science was scientific and hence 'a non-negotiable journey and the destiny of humankind' (ibid.). In support of Sithole (2004) criticism of the way western science is normally viewed, Elzinga et al. argue that, 'since science is socially situated and its activities have direct bearing on the welfare of society, it is unthinkable to allow such an enterprise to develop according to its own dictates' (Ogunniyi and Ogawa, 2008: 6). Le Grange (2002) also put it this way:

> The hegemony of Western Science as a consequence of military, economic and political power means that Western science has not been objectively situated in world history nor have non-Western sciences been assessed in objective ways (p. 69).

The other problem relating to the rejection of the incorporation of IKS into science is the general notion that IKS is not a valid science. There is a general notion that equates knowledge with science, that is, 'western science' proponents not seeing science as one possible knowledge, but as absolute knowledge (Ogunniyi, 2007b; Jegede, 1997; Fleer, 1999). The hegemony of 'western science' is due to the effects of colonization and the assertion by 'western scientists' that IKS is ethnocentric or subculture of 'western science'. This notion is best illustrated by the following quotation:

> ... Western science, because of notions of superiority – based on claims of rationality, objectivity and universality – wilfully privileges its own traditions in developing countries at the expense of indigenous knowledge systems (Payle & Lebakeng, 2006).

Many teachers trained in 'western science' philosophy have such a belief that western science is the only science and that everything else which does not stand western science validation instruments is not science, but some form of superstition. Most of them, due to their limited training do not understand how far science goes, that is, aware of its own epistemic underpinnings and limitations. They believe that all human problems can be solved through science. This is what is called scientism. That is, the construal of science as the only authentic knowledge to solve human problems. As Ogunniyi (2008) has argued, this belief is the perpetuation of the Enlightenment utopia – i.e. a belief that can no longer be defended by sound evidence. If anything at all, human problems have multiplied than reduced. Despite the benefits of Science (and Technology) newer problems have emerged directly or indirectly from scientific and industrial activities.

Some educators, schooled in 'western science', argue that it is difficult to find comparative examples so as to reinforce what is required by the Science-IKS curriculum. Many teachers argue that there are rarely any explicit examples of IKS in the curriculum compared to the conventional school science and for most of the time very little about IKS is assessed in the final examination. This observation is valid and indeed discourages most educators and leaves them with the question, 'why teach something that is not going to be assessed', especially more so that the new curriculum came with a lot of administrative work on the part of the educators? This lack of emphasis in the content of the science syllabus gives teachers the impression that IKS has less value or that it is an extra-curricular subject within school science which is not a prerequisite for success in science examinations.

One other situation which can undermine the progress in the implementation of a Science-IKS curriculum could be the poor representation of indigenous knowledge within the school science text books (Ninnes, 2000). For example, some school science textbooks would only present 'western science' pictures and names of scientists or production process. In the South African case, text books largely represent 'western science' notions of reality and even though C2005 had called for the integration of IKS with school science, assessment of IKS in examination papers is still minimal. For example in 2009 only one technology related question was asked in the matriculation (popularly known as matric) examination. Neither the curriculum developers nor the subject advisers have provided educators with concrete reasons for the status quo. One might suspect that even these do not have sufficient knowledge of IKS. So other than rhetoric and the romanticising of indigenised school science by policy makers and others, educators are left puzzled about how to enact a Science-IKS curriculum in their classrooms.

2.2.2 Fermentation from a school science perspective

The term 'fermentation' is derived from the Latin verb 'fevere' which means to 'boil' (Wikipedia, 20/10/2009). From western science perspective, the first French zymologist (science of fermentation or zymology) was Louis Pasteur. In 1854, he discovered that there was a relationship between yeast and fermentation. At the time he considered that fermentation was a process of respiration in the absence of air, that is, in anaerobic conditions where there is no oxygen. Later, in 1897, German chemist and zymologist, Eduard Buchner, 1907 Nobel Prize winner, made the discovery that fermentation is a process actually caused by a yeast secretion or yeast extract.

According to some science books, fermentation is a scientific process which utilises living microorganisms in converting organic substances into other substances, that is, 'a form of anaerobic respiration of organic substances brought about by microorganism or enzymes' (Hartmann-Peterson & Gerrans, 2001: 98). In food processing, fermentation is generally a conversion of carbohydrates to alcohols and carbon dioxide or organic acids (e.g. lactic acid and acetic acid) using yeasts, bacteria or a combination of them in anaerobic conditions. In the Grades 8 to 9 Natural Science and Technology as well as Grade 10 Life Sciences (Biology) classes, learners are introduced to the processes for food products like 'amasi' (cultured milk), yoghurt, cheese, vinegar and baked bread. Common to the mechanisms of most fermented food products is the conversion of sugars in fruits, carbohydrates and vegetables, e.g. juice to wine, grain to beer, carbohydrates into carbon dioxide which leavens bread as well as the conversion of sugars in vegetables into organic acids which are preservative of the food. There are many complex fermentation processes like the production of vitamins, antibiotics, steroids and production of other chemicals which might otherwise be less economical using normal non-biological chemical processes.

As this study is focused mainly on learners' conceptions of food fermentation, I will list five general purposes of food fermentation as understood from a school context.

Food fermentation has been said to serve five main purposes:

- Enrichment of the diet through development of a diversity of flavours, aromas, and textures in food substrates.
- Preservation of substantial amounts of food through lactic acid, alcohol, acetic acid and alkaline fermentations.
- Biological enrichment of food substrates with protein, essential amino acids, essential fatty acids, and vitamins.
- Elimination of anti-nutrients
- A decrease in cooking times and fuel requirements.

The purposes noted above are common with those understood from an outside school context. Learners come to school being exposed in one way or another to these processes depending on their urban or rural backgrounds. This means that learners in urban contexts might be more exposed to certain types of products and processes that are different from those in rural areas and vice versa depending on the context.

2.2.3 Fermentation from a traditional perspective

Since ancient times it is well documented that human beings have been using and controlling fermentation processes for their well being. This study is concerned with learners' conceptions of fermentation. The interest is to find out how much the learners knew about the products of fermentation prior to their school science exposure, the processes of production (the 'what' and 'how' questions) as well as the rationale (the 'why' questions) of their conceptions or understanding. The NCS document indicates that there is knowledge from IKS which needs to be recovered, hence the infusion of IKS into school science. In accordance with above, Ogunsola-Bandele (2009) adds that 'some of the informal practises from IKS 'may be useful even in the face of formal science, refined and integrated to the same, instead of rendering them obsolete in the societies' (Ogunsola-Bandele, 2009: 54). For this reason, I have mainly focused on the brewing of traditional beer and other related products (cultured milk, vinegar and yoghurts) which learners in urban areas are mostly acquainted with. Most of the learners in the urban areas are born in the informal settlements and townships of Cape Town, but having homes in rural area. They have to go home to the rural areas of the Eastern Cape during school holidays with their parents. For most of the time, many rituals such as initiation of new born babies, initiation of girls and boys who have come of age, funerals, weddings

and other rituals have to be performed at the parent's homes in rural areas. In all these rituals, beermaking is used (the presence and partaking of the beer) as means of connecting and communication to the ancestors when the rituals are performed. Learners who are exposed to these rituals do not only observe them, but are also part of all preparations including the traditional beer brewing.

2.2.4 Tradition beermaking and its associated by-products

The isiXhosa traditional beer is called 'umqombothi'. The main ingredients are maize and sorghum. An initial amount of maize grain or sorghum is usually fermented to produce the associated malts. In some regions where maize and sorghum are planted in relatively equal amounts, equal amounts of crushed maize and sorghum are soaked (fermented) for a few days and then mashed into a paste that is used for cooking a large amount of porridge. Without this pre-fermentation of crushed grain of maize or sorghum grain, it would otherwise be impossible to produce a smooth paste. The porridge is usually cooled down, pitched with a small amount of liquor from pre-cooked porridge and one or two handfuls of crushed malt. The mixture is usually well hand-mixed using the combination of arm stirring and hands in a big drum called 'ifatyi' (derived from the English word 'vat'). This is done so that the mixture is very smooth. The mixture is fermented for another three or four days depending on temperature condition or types of vats used – old wooden ones or plastic. Once the mixture starts to 'boil' (foaming), the mixture is usually filtered with grass-made strainers or filters. The beer is usually opaque and dark brown or light brown depending on the ratio of maize to sorghum, maize or sorghum only. Whilst traditional beer is said to be contaminated with mycotoxins of which many people who consume it are usually diagnosed with oesophageal cancer, the interest of this study is in the understanding of the processes and ingredients used in its preparation. The ethical issues surrounding the selection of a topic involving the process of alcohol production will be highlighted in Section 2.2.6 as well as in 3.10.1.

2.2.5 Associated by-products of traditional beer

Related to the process of beer preparation, different non-alcoholic beverages are prepared including morning sour porridge or 'amarhewu' (A form of a sparkling thirst quencher). All these food products also use fermentation as a process. Most learners are exposed to these products and their preparational methods. Whilst the beer contains moderate amounts of alcohol (about 2–3%), most of the other beverages are not regarded as alcoholic (less than 1%), hence termed non-alcoholic beverages. One other important fermentation product is 'amasi' which is cultured milk. As a boy, I knew of some wild plant fruits that we used to squeeze into freshly milked milk to make our own instant cultured milk or 'amasi'. These fruit had the same effect as vinegar would have in turning fresh milk into cultured milk. As already indicated in 2.2.2 above, that food fermentation is used for many purposes such as changing the taste of food or texture, lowering of cooking time, preservation, etc.; there are countless indigenous knowledge ways of using fermentation that are used in other civilisations.

2.2.6 Rituals and myths in traditional beermaking and its usage

The production and use of the local beer are common daily experiences for learners from the isiXhosa community be it in urban or rural areas. However, its use is usually connected with rituals and ceremonies and the adult community would not tolerate an underage drunkard. Even among adults, drunkards are despised. The issue here therefore is, 'What knowledge of the local beers production process does the learners in this study hold?' If the local beers are part of their life worlds how could their knowledge of the production process, which involves fermentation, be used as a platform for learning the same process in the science classroom? This is the underlying assumption of the study, at the centre of constructivist theory, is the linking of prior knowledge with new knowledge.

One example to illustrate how IKS can be incorporated in a science lesson is to allow learners to discuss what they know about traditional beermaking and then to try and search for scientific evidence (i.e. knowledge based on empirical observations) in their claims. For instance, according to western science, when beer is foaming and overflowing, school science says that microbes in the beer convert the sugars in the starch to alcohol and give off carbon dioxide gas which is seen bubbling to give the foaming that is seen. As stated earlier, in African tradition, beer is brewed primarily for socio-cultural interactions. Traditionally, whenever there is a cultural event it is customary that prior to the event beer should be brewed.

The fermented beer is used as the 'communication cup' between the living and the ancestors whom are believed to be the 'living dead'; that is, though they are physically dead they still communicate with us through the foaming process. This is the reason why when beer has been brewed, one portion of the beer would be put in a private hut or room for the ancestors and before the first person, 'Injoli' (taster and server) partakes of the beer drinking some of the beer must be poured on the ground to soak it. This is done to give thanks to the ancestors who are believed to have caused the ground to yield the raw materials. The presence of foam is not seen as carbon dioxide gas, but as the presence of the ancestors. The beer in the private hut will be constantly monitored for the presence of foam. When the foam has subsided, it is usually assumed that the ancestors have had enough and if the foam overflowed, it is also believed that the occasion was blessed. As already stated in my introduction, learners from traditional isiXhosa backgrounds have a reasonable understanding of biological change from their experience, but would generally have different explanations attributed to those changes. The learners' explanations do not always coincide with the mechanistic criteria of school science which holds veto power as to what science is and what it is not.

2.2.7 Why a Life Science topic, and what do other scholars say?

As a physical science educator my experience is that unlike physical sciences, life sciences are loaded with more concepts and descriptions than formulas. In addition, Life Science assessment questions tend to focus more on questions of what and why about natural phenomena and less of how such phenomena occur the way they do. This is perhaps due to the complex nature of the life organisms which makes it difficult to predict with the same exactitude as is usually the case in the physical sciences. In this regard, Abrams, Southerland & Cummins (2001) have argued that, the other conditioning factor is that life sciences (Biology) and Physical sciences like Physics and Chemistry are distinctively different since the focus of the physical sciences is on the 'how' (process) questions and that the focus of the life sciences is mainly on the 'why's' (the rationales) and less of the 'how' questions (the mechanism or causes).

The observations above are probably what makes life sciences discipline a bit complicated or abstract. The issues and the mysteries surrounding what constitutes life, though beyond the scope of this study, has been the subject of great interest of humans from time immemorial. A study by Dinie & Ogunniyi (2009) about life after death among two cohorts of educators of science showed great disparities in their world views about this subject matter. However, more than three quarters of the educators held strongly to the religious notion of life and death.

If we take into consideration what the new curriculum requires to be done in as far as integrating IKS with school science is concerned, then we can see that a topic in the life sciences dealing with the fermentation process involved in beer production is likely to trigger off a lot of socio-scientific controversies than the same topic in physical science focusing purely on chemical reactions, hence the grounds for situating the study in the former as a platform for argumentation. For example, fermentation is a widely used process in both western science and IKS. However, as indicated earlier, the 'how's' and 'what's' of the process for both world views might be slightly different. When learners come into the school classroom they are required to follow the western science processes of fermentation which are underpinned by western science rationales. Abrams, Southerland & Cummins (2001: 1271) asserts that, 'the ability to explain natural phenomena is a hallmark of scientific understanding' and that, 'students' explanations are mirrors for their underlying conceptions'. Studies from a socio-cultural perspectives argue that science learning is a socio-cultural endeavour and that learners understanding and explanation of natural phenomena is influenced by their socio-cultural background. The authors go on to reinforce their view of western science by citing Hempel as asserting that '[s]cientific explanations are expected to meet two systematic requirements, that of explanatory relevance and testability' (Abrams et al., 2001: 1271). In contrast to the above, Alexander (2009) cites Taylor as making the following statement: 'If you were to ask me what scientific idea I think is most destructive, then I would say the idea that in science we have to test to explain is hugely problematic' (Alexander, 2009: 1).

Abrams et al. (2001) focused on learners understanding of the nature of biological change and came to a conclusion that learners generally have problems in explaining biological changes in organism. In their view:

> Students attribute either human agency to non-human organisms or objects (anthropomorphism) or they use the eventual purpose of an event as the actual mechanism to explain the phenomenon (teleology). In both cases, such explanations are scientifically flawed, as actual physical mechanisms of phenomena are not identified. The use of teleology and anthropomorphism is common by students struggling to understand the nature of biological change (Abrams et al., 2001: 1272).

The citation above by Abrams et al. (2001) focuses on the western science view of explaining natural phenomena. They assert that the learners' use of anthropomorphism and teleology in explaining phenomena are both flawed, since they argue that the actual physical mechanism of phenomena are not identified. The observation by Abrams et al., however reveals that, even learners of European descent who grow up in the western culture do have problems with biological sciences (Aikenhead, 1996; Aikenhead & Jegede, 1999). Also earlier indicated, biological sciences deal not only with microscopic non-observable entities which require some intense imagination on the part of learners, but other issues about life and living which go beyond physico-chemical reactions. The reason for this is that learners neither possess the needed prior knowledge of such microscopic entities nor the biological processes which such organisms have with life. Of course, western science does identify characteristics of living things such as respiration, excretion, movement, irritability, growth, and reproduction. But how organisms are able to exhibit these characteristic matters beyond present scientific knowledge is yet to be understood. But this very critical issue of life and death forms an important aspect of IKS. Perhaps the use of anthropomorphism and teleology referred to by Abrams et al. seems to be an attempt by learners to create subsumers or something to anchor their new knowledge of natural phenomena. However, this issue certainly warrants a more scholarly attention.

Fermentation is a concept whose biological processes involves microscopic entities. Learning the biological processes such as this by learners from indigenous communities seems need a form of border crossing between what they currently know and what they need to learn in the science classroom. This seems to warrant an understanding of the microscopic and counter-intuitive biological changes that occur. A way to facilitate that border crossing is to link what the learners know with what they ought to know. This is as Vygotsky (1978) would call transversing the zone of proximal development or as we would see later what Ogunniyi (1997) calls an emergent cognitive contiguity.

According to Olsher and Dreyfus (1999), 'the biochemical level is quite esoteric for ninth graders, and the learning of the relationships between the macro and micro-systems in phenomena requires a sound understanding of particulate nature of matter' (p. 137). They argue that since learners do not have any prior knowledge about microscopic entities, teaching of those concepts can only be taught by a method they call 'ostention' or by showing the theory in action. They argue that, for instance, if fermentation is to be taught efficiently, learners must be exposed to the processes of fermentation products' production which they call biotechnologies. In the words of Olsher et al. (1999):

> This is the heart of the matter: when the 'ostention' approach is used in the context of biotechnologies, meaningful learning of biological processes may result in the generation of questions, or hypotheses, about the biological function and implications of observed phenomena, and not any more to the learning of esoteric biochemical details (p. 137).

The use of biotechnology seems to be a plausible mechanism of introducing and teaching of abstract biological concepts like fermentation. The good thing about these biological processes is that, their biotechnologies like brewing, dairy products etcetera are reasonably understood by learners from their everyday lives.

Olsher & Dreyfus (1999) refer to the term 'biotechnologies' because the type of teaching and learning intervention 'exploit the capacity of various living organisms to synthesise products which are useful to humankind' (p. 137). As a result of ostension:

> Learners may see what happens as a result of the action of unseen biochemical factors which function within the cell. It is true that these factors remain, as far as the student is concerned, in a kind of 'black box'. However, by showing these processes' in action' the teaching method can bring the learners to a state where they can ask meaningful questions, raise meaningful problems and understand answers concerning the nature of events which 'must have occurred' in the black box, and their importance to the living organism (ibid.)

With regard to the concept of microbes, Simonneaux (2000), speaking from a European context, argues that learners' conceptions with regard to what is commonly known as 'microbes' or 'germs', the learners' knowledge about the immune system usually condition their understanding of current and sought after biotechnologies as well as their ability to discuss those biotechnologies. This could be true, because many learners who are brought up in the urban areas and never went to the rural areas usually throw away milk which is said to have soured. To them, if the expiry date is reached, then the milk is said to be rotten. Their conception of fermentation of milk can be equated

to the concept of rotting of milk. Many children do not eat yoghurt because they think it is rotten. Some fermented products like commercial beer and ginger do not have live cultures, but most of those which are home-made still have live cultures in them. This can also explain the bias against home made fermented products. People tend to think in terms of harmful germs because most of them cannot distinguish the difference between fermentation and the rotting process where harmful bacteria take over, hence releasing toxins into food or even rotten milk.

Summary

Life science as a school topic is construed in this to be amenable to Learning Outcomes 3 of the NCS (which focuses on the nature of science, the impact of science on society and the environment), and which seeks to infuse IKS into mainstream school science. Most topics in Life Science relate to every day life of the learners at school. Observations from both school science and IKS are generally common, but explanations for the apparent observations are generally diverse. School science shown earlier has generally treated life science from a mechanistic view and ignored the interconnectivity of events that underpin the Life Sciences discipline. Major issues of Global Warming and the Environment, HIV/AIDS, Food Security, GMOs and health have demanded alternative views in the understanding and knowledge development in Life Sciences. Finally, life sciences is a fascinating field which exhibits many teaching and learning possibilities. The scientific explanation used in Life Sciences can contribute enormously as a platform for teaching argumentation from a science-indigenous knowledge perspective. It is also amenable to both world views, that of science and IKS.

2.2.8 Implications of the new curriculum for teaching and learning

When learners come to school to learn about science, they usually expect to learn something 'new'. They come with an understanding that science is a very difficult subject that requires amongst other things, a good understanding of mathematics. They are also expected to have a good command of English which is not their home language. Their choice of science is usually based on the future promises of good paying jobs and job security. Their prior scientific knowledge is usually not expected to co-incide with school science. The usual approach in school in introducing fermentation is through a microscoping and abstract approach. They could study a separate section on microorganism, classification of micro-organisms, their physiological structures, adaptation and reproductivity. Another section would be on carbohydrates, empirical formulae, sugars, and so on. In this way, knowledge is compartmentalised and segregated which also results in overlapping of concepts which seems to be unrelated to the learners' mind.

I shall like to illustrate with the following example: if a teacher intends to introduce the concept of fermentation and immediately introduces the learners to abstract biochemical equations, the learners will loose interest as the idea is new to them. The reasons that learners tend to loose interest include the fact that:

- They have no idea of what the teacher is talking about.
- They have no opportunity to disagree with the educator or text since the content is not negotiable.

It is better to teach all concepts relating to fermentation simultaneously and not to nest them to one another. For example, it is easy to understand how to bake bread because one is given a recipe that gives one:

- The ingredients and their purposes
- Their ratio
- Procedural steps and their sequence

If learner did not know what bread was, and was given a piece of bread to look at, taste and smell, then the learner would have some idea of the ingredients involved by associating his/her senses to what he/she has seen, tasted or smelt before. The experience itself will arouse the learner's interest in finding out what the ingredients are and how they were put together. By associating an ingredient with another, the purpose (properties of that substance) may be revealed.

Chiappetta, Koballa & Collette (1998: 51) seem to support my view above by arguing that 'acquisition of declarative knowledge is further enhanced when the presentation of new science content is coupled with culturally familiar objects, examples and analogies, and when the students are provided with regular opportunities to interact directly with the material being learned' (see also, Keys, 1997). The microscopic nature of substances is what gives rationale to western science explanation of natural phenomena. This rationale is assumed to be following logical and valid scientific reasoning. On the other hand, while in IKS properties of substances are equally

understood as in science, different reasons are attributed to the properties of the substances involved.

Learners' problem with science is that often it is counter intuitive, i.e., it does not follow commonsense reasoning based on personal experiences. My view is that the best way to introduce the concept of fermentation to them would be by introducing products of fermentation that they already know or are acquainted with. The educator should let them tell him/her what they already understand about the materials they think are involved, methods of preparation and hence the reasons why they make such observations and claims. In this process learners will have the opportunity to externalise their views through some language which is socially constructed from their communities. According to Young et al. (2005) concepts cannot be understood or used in isolation from the language in which they occur. When learners discuss or argue, they will automatically be making claims and justifications of what they believe and know. Whilst learners are taught that, good understanding of English will enable them to grasp scientific concepts easily, it has been found that the opposite actually occurs. For most people good communication in English is equated with good cognitive understanding of the content knowledge.

As indicated earlier, the language of learning and teaching (LoLT) (which is generally English for the majority of African children in South Africa) is not the language of science. The language of science is not English, but a language socially constructed through observations and experience. These observations are recorded using a 'language' or terminology which is inherited from the language use of the fathers of 'western science'. In many cases these phenomenal observations have terms which are derived from Latin, adapted and adopted into English (Rampal, 2005). Setati puts it succinctly by asserting that:

> Learning mathematics and science has elements that are similar to learning a language since these subjects, with their conceptual and abstract forms, have very specific registers and sets of discourses (Setati et al., 2002: 135).

Alexander (2002) argues that, whilst English is used in all spheres of our lives – education, industry government and in trade, its pursuit without a good grounding in a prior language that serves to facilitate linguistic border crossing will result in the 'chasing of wind'. In simple terms or words, whilst the ultimate goal is cognitive acquisition of English academic language in discipline specific discourse, the primary focus should be on a prior language development and usage. This is the language that the learners maps and navigates through their surroundings, the language of socialisation and ultimately, the language which is the custodian of their prior knowledge. It has been established that once learners are well grounded in the content of a particular learning area, their knowledge can easily be transferable to another language. Concepts in one language can also be transferred into another language, since they are socially constructed.

Alexander (2002) has further argued that chasing after English and neglecting the learners' prior language will result in the diminishing of their cognitive understanding of English high status domains, such as science and mathematics. Chasing after English and neglecting the learners' home language also results in the loading of learners with concepts that they cannot relate to or map them on to anything. The only alternative the learners will have, is to store the information through memorisation, hence rote learning is developed. Because of this learning practice, learners forget completely about what they already know and how their prior knowledge links to what is to be learned and understood of fermentation from a school science context. It is for the above reasons that the analogy about learners' IK perspectives versus school science views seems valid.

Again as I indicated earlier, the two knowledge systems are premised on different epistemic authorities. It is these notions of epistemology that defines the nature of science and IKS. As Abd-El-Khalick & Lederman put it, 'The phrase 'nature of science' typically refers to the epistemology of science' (Ogunniyi, 2007: 965). For scientific knowledge to be valid it must be justified by evidence and reason (Ogunniyi, 2008). In his book titled, The Nature of Science, 'science is a way of knowing and interpreting experiences with nature and the values attached to such experiences which are considered worthy of inclusion in the school science curriculum' (p. 5). What all this seems to suggest is that there are more than one way of knowing and interpreting human experiences with nature. To think otherwise would be to construe science as absolute knowledge about such experiences, but that would be drawing science beyond its purview.

To avoid falling into the error of scientism or the common misconception that the epistemic authority about NOS rests upon its exactness, reliable methodology and unbiased objectivity (Ogunniyi, 2010) educators should present school science in a manner that would enhance learners' awareness of the nature of science (including its merits and limitations). This would help learners to develop a more robust image of science than is presently the case. The benefit of this understanding

is that learners would be able to understand when science is applicable and when it is not applicable when faced with situations of decision making using scientific knowledge. To achieve the above goals, educators would need more than just science education which is normally the case. Ogunniyi, et al. (1995) argued that, education in science does not guarantee that educators would transmit valid views about science to their learners or that they would point out the limitations of the alternative conceptions held by their students. IKS, on the other hand refers to a 'conglomeration of knowledge systems encompassing science, technology, religion, language, philosophy, politics and other socio-economic systems (Ogunniyi, 2007: 965) and that it is not only about artefact, but epistemologies, ontologies and metaphysical systems underpinning the artefacts (ibid.). With these differences in mind, several questions arise as to what strategies will make it possible so that:

- There will be no conceptual conflicts in the classroom as a result of educators and learners not knowing which scientific explanation to reinforce in the process of teaching and learning.
- Educators and learners know what to do with the IKS alternative ways of explaining natural phenomena.
- Synergies between the two systems can be identified in order that science learning can be accelerated.

The list is by no means exhaustive of all other ways of viewing the issue of IKS interfacing with mainstream science. In summary, the central question regarding a Science – IKS curriculum would be, as can be put in the words of Onwu and Mosimege (2004: 1) that, 'Central to all of this is whether to accord, in the new science curriculum, indigenous and scientific knowledge equal but different status; to view them as derived from competing or complementary world view.' Onwu (2009) further adds that some issues regarding the integration of IKS into the classroom science still remain 'murky', that is, the question of what kind of IK should be included (p. 22). In order to arrive at answers as to what strategies to use when infusing IKS into science, certain socio-cultural realities of our multicultural classrooms have to be addressed. Addressing these, would not be the end, but a means to an end. In the following section I am going to elaborate on the 'means' or simply put, the understanding and recognition of the scenarios that are possible which will warrant the kind and nature of teaching and learning strategy which I have proposed.

2.2.9 Socio-cultural perspectives in learning science: What do scholars say?

The realities in the classrooms are that learners move to and fro between their home environment and the school environment. Learners generally come to school having their own understanding of the world around them. Learning of classroom science requires that these learners adopt and adapt to the new way of thinking with its language genre. Aikenhead & Jegede (1999) put it succinctly in the following way:

> Whenever pupils enter the world of school science, it soon becomes evident that science too, is another culture with which s/he has to interact, bringing with him/her the other baggage of cultures s/he already carries. It does not take too long for the pupil to recognise that the science being taught at school has been influenced by the culture of the scientific community itself (p. 46).

Keys (1997) agrees with the above scholars, also asserting that, ' school science objectives often deal with assimilation and understanding of concepts constructed by prominent scientists over centuries' (p. 958) and further emphasises that, 'reconstructing an understanding of these concepts requires students to link together many pieces of declarative knowledge that are sometimes quite abstract' (ibid.). The phenomenon described by Keys is what I call concepts indigestion due to concepts overloading. The deductive/inductive reasoning and language that governs the science content structuring is a heavy simulation task on the cognitive structure.

In this section I would like to discuss the notion of border crossing and its role in the process of teaching and learning. As put forward by Ogunniyi (2008), border is a described as the struggles learners engage themselves with as they attempt to reconcile their world views with school science. These struggles are due to the different epistemic authorities within the different world views. As discussed elsewhere, the teaching practice prior to C2005 had been one of a 'chalk and talk' system where the teacher was the sole authority and knower who must transfer knowledge to the learner. C2005 shifted the teaching and learning emphasis towards a learner centred and an outcome based one. The policy looked good on paper, but the envisaged outcomes did not materialise. Those learners who made it, made it through their own devices. The failure, as has been confirmed by the Department of Education (DoE, 2009), was in the implementation of C2005. While the Ministerial Final report admitted that the problem was implementation and tried to identify the issues and the nature of the challenges, the task team gave a range of what they saw as the problems. The report did not focus on issues of the diverse epistemic beliefs that are crucial if it intended interfacing the two. Lastly, the task team did not give any detail of the classroom instructional approach that warranted the interfacing of the two world views.

Some scholars have proposed some forms of border crossing models, that is, collateral learning by Jegede (1995), Cultural Border Crossing Theory by Aikenhead (1996), the Contiguity Learning Hypothesis by Ogunniyi (1995) later Contiguity Argumentation Theory (CAT) (Ogunniyi, 2007 a & b) as well as the Cognitive Border Crossing Learning Model by Fakudze (2004). All these forms of border crossing attempt to explain why learners from diverse socio-cultural background experience cognitive conflicts when exposed to school science. The underlying assumption that underpins all forms of border crossing would be socio-linguistic border crossing. I therefore would contend that awareness of socio-linguistic or cross-linguistic border crossing can help clarify how learners from diverse socio-cultural backgrounds experience cognitive conflicts at school.

2.2.9.1 Collateral Learning (CL)

Collateral learning as proposed by Jegede (1995) is a mechanism to explain how a learner harmonises the conflict resulting from the interaction between his/her traditional world view and that of school science (Ogunniyi, 2008). For instance, a learner coming from a rural background into a science classroom is not likely to find the scientific world view coinciding with his/her culturally embedded world view. Jegede identifies four ways in which the learner attempts to reconcile the apparent mismatches in his/her mind. They are parallel, secured, dependent and simultaneous collateral learning. Parallel, refers to two or several entities that run along each other and never coincide. One typical scenario would be that, learners who grow up being taught that traditional beer (Umqombothi) is a means of uniting the family with the ancestors will generally keep that knowledge to him/herself as it is sacred knowledge and knowledge on which his/her livelihood and health depends. This learner will learn the other meanings attached to beer in the classroom and use that knowledge for examination purposes only. The second type is called secured collateral learning. One illustration would be to use yeast and bread mould as examples. Learners from indigenous backgrounds generally do not associate yeast (which is used for making fermented beverages such as ginger beer) with moulded bread which is sometimes used for making some traditional beers. Well planned lessons whose goals is to entrench a conceptual understanding of fungal activities and their characteristics can help learners develop secured border crossing where the school science conception of yeast interact with the IKS yeast alternative which can either be moulded bread or moulded maize grain (also containing the fermentation fungus).

Whilst learners had developed the conceptual understanding they will use the knowledge in different ways. For example people know when to use yeast and when to use moulded grain when making traditional beer. In the case of secured collateral learning the context will dictate to the learner which behaviour to exhibit. Dependent Collateral Learning is a situation that one world view explanation challenges the other world view to an extant that the learner seeks to adjust his/her way of thinking regarding a particular concept. When provided with experimental evidence in a laboratory, learners usually adjust their old way of thinking about yeast as a chemical, but still hold to some notion of 'chemical' , since yeast is usually closed and packaged in plastics and its physical structure not indicating any resemblance to something alive or even dead for that matter. The last type of collateral learning, Simultaneous Collateral Learning, depicts a situation where one world view can present precisely fitting analogous situation to learning a new concept. The use of germinated seeds for fermented traditional beer is a good analogue for driving home a concept that fermentation is as a result of micro-organisms acting on cereals (substrates) to produce alcohol. Since germinated seeds are viewed as rotten mealies, it is assumed that the mealie grains are infested with micro-organisms. As a summary, the purpose of the proposal for collateral learning can be expounded in the words of Jegede & Aikenhead (1999):

> The phenomenon to which collateral learning refers is universal and well known worldwide and the theory was proposed to explain why many pupils, non-Western and Western, experienced culturally related cognitive dissonance in their science classes (p. 274).

In conclusion, collateral learning theory as a cognitive explanation of cultural border crossing is a useful learning and teaching theory that curriculum developers and teachers should be aware of in the processes of developing curriculum materials.

2.2.9.2 Cultural Border Crossing (CBC)

As in Collateral Learning, Aikenhead (1996) theory can be best explained as the 'act of cultural border crossing into school science' (Jegede & Aikenhead, 1999: 275). They further assert that, 'to acquire the culture of science, pupils must travel from their everyday life-world to the world of science found in their science classroom' (ibid.). Their theories explain possibilities or situations that can occur in a multicultural classroom. Aikenhead used different terms to explain how the transition from one world view takes place. Instead of what Jegede calls Parallel Collateral learning, Aikenhead acknowledges that there are commonalities and situations, depending on a particular topic or context, where the two world views might match perfectly. He calls this situation, Smooth Border Crossing (SBC).

In almost every dimension of life, whether it be in food processing, agriculture, conservation of the environment and other disciplines, there are commonalities between the two systems. For various reasons, the explanations of the peoples' experiences are different. In brewing of traditional beer, women cover their heads as a sign of respect to the ancestors whereas in the western science explanatory sense, covering of head is required for hygienic purposes. One not familiar with isiXhosa culture might assume that this practice implies ignorance about hygiene. However, a counter argument is that, in order that hygienic practices can be maintained, moral values are needed; hence the respect of ancestors is emphasised as an overarching principle. Aikenhead does not specify a situation where the two world views do not interface, for example, issues of faith and those of scientific testability. The second form of transition depicted is Managed Border Crossing (MBC) where he also acknowledges that there are situations where there the two world views will be different as has been discussed earlier.

The third form of border crossing envisaged is called Hazardous Border Crossing (HBC) where the two world views are so separated apart such that what can be foreseen in a classroom is lot of tension and cognitive conflicts due to the abstractness of school science where there is a strong deviation from commonsensical explanations within school science. The last form is called Impossible Border Crossing (IBC). Aikenhead sees this situation as hazardous such that the learners will resist learning of a new concept due to the degree of diversity of the new concept. This situation is one that can be envisaged if the curriculum developers are not careful in as far as what IKS or Science components should be integrated in the new curriculum. These were some of the concerns posed forward by the debate between Onwu and Mosemege (2004). The debate centred around what aspects of IKS could be incorporated into school science and what status to be accorded to each world view presupposition. Jegede & Aikenhead (1999: 276) also cites a situation which they term 'cultural violence' where cultural border crossing is at high risk of failure due to extreme cultural difference. In the context of fermentation process, one learner might be against certain activities such as tasting of beer or alcohol due to religious beliefs. This learner might not be in the position to gain the necessary experience in processes of observation exercises. As a result, this learner might not be able to participate in argumentation or be able to write anything for assessment purposes. Understanding and awareness of cultural border crossing can enhance the attitudes and values of the teaching practice. In this case a learner would gain vicarious experience by asking others or simply smell the alcohol instead of actually drinking it so as to participate in the discourse. But even if he/she refuses to do this he/she should be allowed to maintain his/her independence. After all, the purpose is not to indoctrinate the learner but to develop appreciation for other world views.

2.2.9.3 Cognitive Border Crossing Learning Model (CBCLM)

Fakudze (2004) used three theoretical constructs of Border Crossing, Collateral Learning, Cultural Border Crossing and Ogunniyi (1995) Contiguity Learning Hypothesis. She combined all the three models of border crossing and proposed the Cognitive Border Crossing Learning Model model , which she argues encapsulates all border crossing scenarios. In her observations in attempting to verify the applicability of the three constructs of border crossing, she concluded that none of the three theoretical constructs could fully capture the process of border crossing when treated alone. She further asserts that the assertion by the Contiguity Learning Hypothesis (CLH), that the process of border crossing was as a result of a combination of physiological, psychological and metaphysical phenomena still needed empirical confirmation.

As far as border crossing scenarios or contexts, there could be other situations that are dependent on the nature of what needs to be learned and what strategies are used in each case. Teaching and learning strategies to my mind would be influenced by one's understanding or assumptions about what and how learning takes place. Learning, generally speaking is a process of influence by either concrete evidence, emotional or cultural interest and

even economical interests. These, then would assume physiological (how the brain works), psychological (emotional influence) as well as metaphysical (spiritual beliefs or cultural beliefs) (Ogunniyi, 2008).

Border crossing is a reality for classroom practice, but what is important how to manage that border crossing so that transitions from one world view to another are smooth. The border crossing theories seem to be a mechanism that attempts to explain situations under which cognitive conflicts can occur, but do not provide the bridge itself. The type of bridge in each context will be what the teacher will construct in the classroom in order to avoid cognitive conflicts as much as possible. This study is concerned with proposing the type of bridge that can be constructed so that learners can construct and reconstruct their own knowledge.

2.2.9.4 Socio-Linguistic Border Crossing (SLBC)

In a multicultural society, like in South Africa and else where different cultures usually come into interface; language is usually the vehicle that is used as means of crossing cultural border bridges. Regarding the relationship between language and science learning, Sutherland and Dennick (2002: 4) make the following assertion:

> The relationship between language and science learning requires further exploration since research on the role of language plays in the understanding of science is still unclear. The use of language as the means of communicating scientific understanding by children has not been extensively explored. However, cross-linguistic research shows that different meanings in different languages account for many common misconceptions, and there are some suggestions on how language influences learning.

Critics of like Lemke as cited in Scot et al. (2007) have put forward an argument that science can only be learned by participation. Lemke is quoted as saying that, learning science involves learning to talk the language of science and acting as member of the community of that practice. Learning to talk science does not occur in a socio-linguistic vacuum. The phenomenon of Cultural border crossing is a testimony to the above fact and that the issue of language is not a one sided issue. In addition, the NCS document of the Department of Education in South Africa (DoE, 2002) does attest to the fact that IKS contains knowledge that needs to be rediscovered and unearthed. Odora-Hoppers (2005), emphasises on the important role that language plays from a socio-cultural perspective. She asserts that:

> Language plays a crucial function in that it contains the map of the land, the relationships to the energies and spirits of all living things – rocks, trees, plants, birds and animals. The flux in which they live is perfectly expressed in what could be termed their 'process language' (p. 6).

She further draws comparative contrasts between language as used in Western science and that in IKS. She argues that, 'The western physical reality is that of objects in interaction with one another' (p. 6) while 'In IKS communities, language contains movement, progress and transformation – that is, nouns as objects emerge in a secondary way through the modification of verbs. She makes an illustration, that in the western mind, healing is transitive business in which a doctor (a noun) acts upon the patient (another noun) to bring about some change. Contrary to the Western norms, healing is a process (Odora-Hoppers, 2005).

Other critics have argued that African language lacks the registers that are required in learning science, since science uses 'exact and precise words'. For instance, McKinley et al. is cited by Sutherland and Dennick (2002: 4) as arguing that, 'science taught in English for Maori students loses information on translation.' Some examples usually alluded to, are those of colour. In school science there are many colour variations that have English names and argument is made that some African languages do not have their 'equivalences' or correlates to English science concepts. I would like to know what is actually meant by 'equivalence'. If it means not having a one-to-one correspondence of a name, then I would agree (Sutherland & Dennick, 2002: 4), but if it means that, that a certain colour does not exist in an IKS perspective or that indigenous people are colour-blind, then I would disagree. In isiXhosa we call a blue colour using the same word for a green colour. When we see a blue colour we say 'it is "green" as the sky' and a green colour just green. The word 'green' (luhlaza – isiXhosa) carries a meaning for a green and a blue colour. People from an IKS background know the primary colours of light very well and hence do not struggle to see combinations of those primary colours. Cole and Scribner (1974) also cites Werner (1961) as asserting that the Kamayura Indians of Brazil do not make a distinction between blue and green since 'spots of either colour are designated by a single word, meaning parakeet' (p. 2). In support of my view from an isiXhosa cultural perspective, Cole & Scribner assert that the observation such as is found among amaXhosa or the Kamayura Indians is taken as evidence that such people 'manifest a 'diffuse conceptual construction' with respect to colour concepts' (ibid.).

In the context of fermentation, germinated seeds (a noun) in English, but a verb in is isiXhosa (imithombo), meaning 'to start'. This 'starting' refers to something that causes the starting or initiation of the process of fermentation.

Scot et al. (2007) construe science as a social language that has been developed within the scientific community. It is this social language that Sutherland and Dennick refer to as being responsible for many common misconceptions in science. Cultural Border Crossing encapsulates this socio-linguistic border crossing phenomenon.

As a conclusion, the purpose of this section was just to give a hint to the dangers of underrating the role of language in a socio-cultural context. The arguments put forward on behalf of the four border crossing equally apply to the role of language. Jegede & Aikenhead (1999), articulate it in this way:

> When language or conventional actions of a group have little or no meaning to a person who happens to be immersed in that group and who needs to accomplish some action, the person can experience cultural violence (p. 275).

The above argument is supported by Sutherland and Dennick (2002) when they assert that:

> Discourse patterns differ across languages and cultures. The means by which students for whom English is a second language convey scientific explanations is influenced by the conventions of discourse in their mother tongue (p. 4).

While it is argued that recognition of learners' socio-cultural background is vital, it is questionable as to how to manage the socio-linguistic incongruities that are much responsible for the linguistic mismatch that happens in the teaching and learning of school science.

2.3 Practical considerations

2.3.1. Introduction

As the National Curriculum Statement of the Department of Education in South Africa (DoE, 2002) recognises the nature of classrooms in the new South Africa and hence enacted a policy to infuse IKS into the school curriculum, it further hinted to the notion of border crossing as saying:

> [...] One can assume that learners in Natural Sciences Learning Area think in terms of more than one world-view. Several times a week they cross from the culture of home, over the border into the culture of science, and then back again (p. 3) and (Ogunniyi, 2004: 291).

Different forms of border crossing have been explicated, depicting the conditions under which those forms of border crossing have been observed (See Jegede, 1995; Aikenhead, 1996; Fakudze, 2004 and Ogunniyi, 2008).

2.3.2 Enculturation into school science

According to Fleer (1999, 121), 'In order for individuals to begin to appreciate meaning systems and the processes of knowledge construction in another culture, the two cultures must come together and exchange world views.' Border crossing, is a natural process necessary so that learners from a socio-cultural background can be introduced to school science. The statement by Fleer suggest that the two systems of thought (science and IKS) should speak to each other or that learners should be able to make sense of their new experiences without losing their current IKS views. Ogawa 1993 asserts that:

> … The Japanese never lost their cultural identity when introducing western science and technology, because they introduced only the practical products of western science and technology, never its epistemology or world view (Ogunniyi et al., 1995).

According to Ogunniyi et al. (1995), several studies from a socio-cultural perspective have revealed that, 'alternative conceptions about natural phenomena are not easily replaceable by scientific world view' (p. 819). It is in this regard that other scholars such as Erduran (2006) have argued for a teaching and learning approach that is premised on argumentation. Erduran argues that, argumentation is a critical tool for science learning so that learners from different socio-cultural backgrounds can be in a position to appropriate their IK as well as that of school science. She further asserts that:

> If enculturation into scientific discourse is significant to science learning, then it becomes imperative to study such discourse to understand how the teaching and learning of argumentation can be traced, assessed and supported (Erduran, 2006: 16).

There seems to be a consensus that argumentation as a teaching and learning tool is able to mediate the learning of school science so that the learning of school science does not create scientism in learners, but that they should be able to understand the limitations of each system of thought (Simon, Erduran & Osborne, 2006). Newton (1999) also argues that science is a social construct. In supporting of his view, he asserts that '[t]his perspective recognises that observations are theory laden (Hanson 1958, Kuhn 1962) and, therefore, that it is impossible to ground claims for truth in observation alone …' (p. 554).

He asserts that scientific claims are grounded through a process of argumentation which is used to construct plausible links between claims made and the available evidence. In addition, the evidence itself is open to interrogation, 'both in terms of the way that it is framed conceptually and in terms of the trust that can be placed in its reliability' (ibid.).

Curriculum 2005 calls for the integration of IKS into school science and hence also emphasises that both world views should be acknowledged and accorded the same status (DoE 2002). The NCS documents for Grades 10–12 and RNCS Grades 8–9 also encourages group work activities and discursive classrooms. The only problem is that, C2005 does not come up with the kind of strategies that will encourage valid group discussions or arguments as highlighted by Newton (1999) and Simon et al. (2006). Teachers who for most of them have learnt science from a western perspective are expected to create discursive classrooms also infusing a world view that is incompatible to school science. C2005 outcomes-based approach stresses the need for learners to work in groups as to enable them to talk to one another and to be engaged in discussions, hence developing their reasoning processes skills.

While the new curriculum has emphasised that the way forward in teaching and learning, was group work in form of activities that are expected to achieve certain outcome, it did not spell out what the teachers should actually do in class in order to facilitate effective group work. This, as stated earlier, is a front challenge for educators. Learners are usually left alone to work in groups and to discuss issues. While argumentation does enhance the learners understanding of the content, if it is not facilitated with clear goes with regard to argumentation rules, the content to be learned as well as the nature of the content, the learners and teachers will be left confused as to what they were trying to achieve by the end of the lesson. Simon et al. (2006) argue that, 'science education requires a focus on how evidence is used to construct explanations …' (p. 236) and that, ' the teaching of argumentation through the use of appropriate activities and pedagogical strategies is, we would argue, a means of promoting epistemic, cognitive and social goals as well as enhancing students' conceptual understanding of science' (ibid.).

The forms of border crossing observed and explicated, I believe, might be given more meaning if argumentation as a teaching and learning framework is given precedence in the classroom practice. Ogunniyi (2008: 11) summarises it this way:

> From socio-cultural and psychological perspectives interactive classroom arguments and dialogues can help teachers and students to clear their doubts, upgrade current knowledge, acquire new attitudes and reasoning skills, gain new insights, make informed decisions and even to change their perspectives ...

2.4 Summary

Scholars from a socio-cultural constructivist approach have argued that science learning is a culturally influenced phenomenon. They have therefore proposed that teachers should be able to 1) recognise that, 'western science as being a cultural entity itself; 2) acknowledge the cultural border crossings that most students experience to varying degrees when moving from their life-worlds into the world of school science, and therefore, acknowledge that learning science is a cross-cultural event for most students; 3) consider the various ways students deal with deal with cognitive conflicts arising from cultural clashes, use collateral learning theory to make sense out of these conflicts; and 4) help students negotiate their border crossings and help them resolve any cultural conflicts' (Aikenhead, 1999: 180). Point 3 above asserts that, collateral learning theory by Jegede (1995) that can explain the cognitive conflicts experienced by learners from a socio-cultural background and thus, as illustrated by point) that, teachers can then be able to help learners to negotiate their border crossing. Whilst the border crossing explanations of how learners from a socio-cultural background experience school science is plausible and very useful, the theory underrate the teachers' lack of understanding of both NOS and NOIKS. Furthermore, the two systems of thought must be able to talk to one another and exchange world views (Fleer, 1999: 121; Le Grange, 2004: 206) and that the two world views should argue on equal grounds (Ogunniyi & Hewson, 2008; DoE, 2002). Jegede (1997) cites Driver (1983) as asserting that '[i]t is possible and important to be able to understand alternative interpretations, to those suggested by other pupils or other scientists, without necessarily believing any of them' (Jegede, 1997: 11). The above assertion by Driver is in concordance with the view espoused by Ogawa in Ogunniyi et al. (1995), that the Japanese introduced only the practical products of western science and technology, but not its epistemologies.

Erduran (2006) argues that, science has advanced through argumentation; however as has been indicated by Simon et al. (2006), argumentation as an instructional tool only comes by practice. One of the challenges posed by curriculum 2005 (C2005) is that it does not explicitly specify how learners should be engaged in argumentation classroom discourse. Arguments of any kind are based upon premises or statements articulating the grounds for which a claim is made. It is these premises that will determine whether or not one believes the claims that are made. Another challenge of C2005 is a lack of a clear guidance or explicit protocol in defining argumentation for diverse world views that it seeks to interface together. Argumentation for western science is premised on a deductive-inductive form of reasoning. This argumentation approach, although favoured for enhancing learners' and teachers' understanding of NOS, it is inapplicable for an IKS-based non-logical and metaphysical form of reasoning. In order that the two world views exchange meaning systems as articulated by Fleer (1999), there must be a recognition and acknowledgement of each other's world view epistemic authority. It is this realisation that, border crossing learning models and other argumentation models that are not explicit in their instructional approach, are deficient. In conclusion, Ogunniyi (2008) in his paper entitled, 'Border Crossing Between Distinct World Views' argues that, border crossing have not yet explained how individual learning experiences of learners result in the different border crossing categories. He added that, the border crossing learning theories also have not yet explained the physiological and psychological processes that bring about the smooth or hazardous border crossing among learners who are exposed to school science.

Before concluding the discussion so far, it seems reasonable to point out that, in order for learners to cross from one world view into another, argumentation should be the over-arching learning theory. If both thought systems are deemed to be equal and both thought systems understood, then areas or commonality could be explored. According to Ogunniyi (2008), the learners' cognitive structures are consisted of their commonsensical or intuitive knowledge, their indigenous knowledge from their society as well as that of school science. He argues that the three world views are in constant contact, arguing with one another on a microscopic level as well as on a macroscopic level when learners argue with each other. Unlike the collateral learning theory (which 'represents the process learners in non-western classrooms constructs, side by side with minimal interference and interaction, western and traditional meanings of a simple concept' (Jegede, 1997: 11), Ogunniyi (2008) has argued that the process is over simplified.

Ogunniyi (2008) has argued that learning is a complex mental process. He argues that each of the three world views wrestle and strive to dominate each other. In one context a dominant world view might become latent while a previous latent one might become dominant (Ogunniyi, 2008). He has explicated this further in his Contiguity Argumentation Theory (CAT) by suggesting that there are at least five ways in which an idea can move in a learner's mind depending on the arousal context. An idea that is *dominant* in one context can become *suppressed* or become *assimilated* into a more dominant idea in another context. He uses the term *emergent* for an idea that might in fact be completely new to a learner as would be most of the microscopic concepts he/she learns in school science such as atoms, genes, molecules, etc. In that case the learner is able to accommodate the new idea or experience into his/her cognitive structure. Yet in another context an idea might co-exist with a distinctively different idea and exert equal cognitive force on the learner's world view as might be the case when a learner accepts the creationist's and the evolutionist's views of the universe. He labels this cognitive state as equipollent (Ogunniyi and Hewson, 2008). More details of the CAT will be provided later on.

2.5 Theoretical framework used in the study

This study is underpinned by a Dialogical Argumentation Frameworks (DAF) as espoused by Toulmin (1958) Argumentation Pattern (TAP) and Ogunniyi (2002) Contiguity Argumentation Theory (CAT). The two theoretical constructs were chosen based on their appeal to a constructivist paradigm and their adaptability to the epistemic authorities of science and IKS. While argumentation has many advantages over other teaching and learning strategies, its advantage lies in the fact that it follows the traditional deductive and inductive reasoning approach which is a good instructional method for enhancing teachers' and learners' understanding of the nature of science. According to Aleixandre (2002), argumentative dialogue like TAP externalises argumentative reasoning which is called substantive arguments. In order to use TAP, content knowledge becomes requisite. The CAT on the other hand has advantages over TAP, in that it caters for both logical and non-logical argumentation explanations (as in the case of IKS and science). The word 'Dialogue' refers to some notions of argumentation for the

purposes of reaching some consensus (Newton, 1999) with regard to some world view diversity. According to Ogunniyi (2007a):

> Argumentation is a statement or constellation of statements advanced by an individual or a group to justify or refute a claim in order to attain the approbation of an audience or to reach consensus on a controversial subject matter such as integrating science and IKS. (p. 965)

Lawson is also cited as asserting that, 'effective instruction encourages an atmosphere where ideas may be raised and then be contradicted by evidence and the arguments of others' (Ogunniyi, 2008: 173)

It can be argued that the purpose of education is to help mediate between the learner and the 'material' to be learned. Langenhoven (2009) lists some rationales in support of an argumentation theory as a means of enhancing the teaching and learning of science and IKS in South Africa. He asserts that, the topmost rationales are:

> The effectiveness of argumentation in facilitating classroom dialogues, especially on controversial issues; various government policy documents supporting the need to make science relevant to the socio-cultural background of the learners; and the need to equip teachers with both content and pedagogical skills to implement the new curriculum mandating teachers to integrate indigenous knowledge with school science (Langenhoven, 2009: 74).

Science as a body of knowledge has been said to be constantly changing and growing. It has also been argued that science changes due to its tentativeness which is in turn stirred and reshaped through arguments (Erduran, 2006; Newton, 1999). From a socio-constructivist philosophy, learning is construed to be as a result of the interaction between the learner, the environment as well as cultural predisposition. These notions suggest that there must be some conversation taking place between the learners' knowledge and the incoming knowledge until some forms of border crossing are observed. This conversation is in order that the learner can digest and make sense of his/her new experiences. As Newton (1999) has succinctly put it:

> Active participation by learners in the discourse of lessons is therefore central to providing an enabling learning environment. Talking offers an opportunity for conjecture, argument and challenge. In talking, learners will articulate reasons for supporting particular conceptual understandings and attempt to justify their views. Others will challenge, express doubts and present alternatives, so that a clearer conceptual understanding will emerge (p. 554).

Generally, classroom practice has always given learners no alternatives about what or not to believe. In order to creating a breeding ground for dialogical argumentation, certain teaching and learning approaches should be employed. Stears et al. (2003) gives the following suggestion:

> Learners' everyday knowledge and purposes can be used in the curriculum in a number of ways. As a starting point for learning science, as a reference point for thinking about the nature of science, and as a context for applying scientific ideas and skills (p. 111).

Stears et al., steps for incorporating learners' everyday into school science seems to be suggesting that a teaching and learning strategy that will allow learners to compare their everyday knowledge with science, is necessary. To think about the nature of science, learners will have to be in a situation to evaluate the epistemic authority of the school curricular using their own everyday knowledge as reference point. According to Ogunniyi and Hewson (2008: 146), claims and counter-claims on any subject matter can only be justified if neither thought system (e.g. science and IKS curriculum) is dominant over another.

The above strategies necessitates that the Department of Education sets its priorities straight, regarding what it regards as outcomes that will develop learners with valid views of science. This implies that, learners will develop valid understanding of the nature of science, i.e. the processes, products as well as the values that are associated with its use.

When learners are convinced of a notion of science, they tend to 'own' that knowledge. A learner who owns a given world view is likely to use it. A learner who is not convinced about a certain position might be able to keep it by memorising it and will likely regurgitate it when required for examination purposes. However, he/she might not be able to use it in an unfamiliar context since it was never internalised or owned. The learning material by its nature is a conglomeration of claims, data and grounds backing those claims. This, as Newton (1999) has argued, necessitates that learners be in a position to talk in the process of learning science, thus a means to externalise their thoughts and views on any subject of interest, the results of which, learners will have an opportunity to air their misgivings (Ogunniyi, 2007a, 2008).

2.5.1 Toulmin Argumentation Pattern (TAP)

Toulmin, a British philosopher, was born in 1922 and died in December 2009. Through his life, he was interested in developing practical argument which can be used to evaluate ethics behind moral issues. His work was also found to be useful in analysing rhetorical arguments. Much of Toulmin's work was influenced by an Austrian born British philosopher, Ludwig

Wittgenstein whose interest was in the relationship between the uses and the meanings of language. Wittgenstein's theories became a theoretical framework of Toulmin's doctoral dissertation, entitled 'An Examination of the Place of Reason in Ethics' (http://tip.psychology.org/guthrie.html.1–5). As indicated in the last section, TAP utilises a deductive–inductive approach in analysing arguments. This approach leans more towards the normal school science way of formal or logical reasoning (Ogunniyi, 2007a).

2.5.1.1 The elements of TAP

As cited by Ogunniyi (2008) Toulmin's Argumentation Pattern (TAP) consists of a claim, evidence (data), warrant, backing, rebuttal and a qualifier. Accordingly, claim, evidence and a warrant are the main ingredients of a practical argument while the other three may or may not be necessary in the justification of a claim.

- **A Claim –** Statement or beliefs about phenomena whose merits are in question.
  School science learning material consists of statements that are conclusive which warrants that before learners can understand them, they question them in order to make sense of what they are to learn.
- **Evidence** (Data) – facts or evidence used for supporting a claim.
  The learner has to read through the facts or experimental observations, tables, graphs etc. and try to make sense out the data.
- **Warrant –** statements used to establish or justify the relationship between the data and the claim.
  One of the challenges that learners find when reading learning materials or in discussions is being able to find valid links between the claims and the evidence. They do not interrogate the evidence to see if it is valid or if it has anything to do with the claim or vice versa.
- **Backings –** Implicit assumption underpinning the claim.
  In many instances, the teaching and learning material in science makes many generalizations about a specific claim. These generalizations are governed by common experiences surrounding a particular claim. Science learning is sometimes complicated by having to differentiate what evidence is and what a backing or supporting information is.
- **Qualifiers –** Conditions governing the claim.
  A typical example of a claim requiring a qualifier would be:

'Traditional beer causes oesophageal cancer'. This sounds true, but not every beer sample contain the toxin that causes the disease nor do all who consume traditional beer develop the disease. This statement or claim is true provided that fungus is found in the sample of beer; hence a qualifying statement should be included with the claim. Other factors might also be involved such the 'body chemistry' of the drinker, the amount of beer consumed etc. However, including the term 'probable' makes the claim less assertive and less categorical and hence less likely to be error prone. This is another important aspect of argumentation which needs close attention in the process of teaching and learning. This phenomenon can also be observed in multiple choice questions where many statements appeal to be true, but tend to be false because of the absence of relevant qualifiers in the statements.

- **Rebuttals –** Statements which show the claim to be invalid (Ogunniyi, 2008, p. 4).
  The process of learning requires sifting of information by carefully looking at the grounds given in the justification of a claim before deciding whether or not a particular claim is valid. Generally, school science approach will involve and integrate the above argumentation elements in the processes of justifying or rebutting of claims made.

Besides, the process of reading or verbal arguments, Toulmin's argumentation model can be used to analyse learner scientific reports or the tool that learners use in the process of writing scientific reports (Kelly & Bazerman, 2003). Studies conducted by Kelly and Bazerman indicate that, students who were successful in their report writing 'were shown to adjust the epistemic level of their claims to accomplish different rhetorical goals, build theoretical arguments upon site specific data, method, introduce key concepts that served as anchors for subsequent conceptual development, and tie multiple strands of empirical data to central constructs through aggregating sentences' (Kelly and Bazerman, 2003: 28) For purposes of classroom practice and the teaching and learning of science, Toulmin's argumentation framework has been found to be useful, since teachers do not usually mobilise arguments the way envisaged in C2005 or other curricula (Erduran, 2006; Ogunniyi, 2007a). In conclusion, TAP is envisaged as a tool for analysing school science practical arguments that follow straight forward logical reasoning and non-controversial socio-scientific aspects of school science.

2.5.2 Contiguity Argumentation Theory (CAT)

As related by Ogunniyi (2008), CAT is a learning theory rooted in the Contiguity Theory and lends its origin to the Platonic and Aristotelian era. According to its origins, this theory asserts that '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.' In contrast to the TAP, 'CAT deals with both logical or scientifically valid arguments as well as non-logical metaphysical discourses embraced by IKS' (Ogunniyi & Hewson, 2008: 146). CAT is premised upon the notions that, claims or counter-claims on any subject matter within competing thought systems (like in science and IKS) can be valid, only and if only neither thought systems dominates the other (p. 146). What can be gathered from the premise that governs CAT is that, successful integration of IKS into mainstream science curricula in South Africa will then necessitate that the two thought systems be accorded the same status. The rationale for according IKS the same status as school science is that IKS possesses knowledge that western science has not yet learned to produce, but which must be rediscovered (DoE, 2002; Ogunniyi, 2007a).

According to Ogunniyi (2007a), the juncture, place or area of commonality between two distinct ideas is what he calls 'contiguity'. It is at that symbolic location or intellectual space where ideas or world views overlap that cognitive processes occur resulting in conceptual conflict, elaboration, accommodation, integrative reconciliation and adaptation (Ogunniyi, 1988; Ogunniyi et al., 1995; Ogunniyi, 2004, 2007a and b)

Dominant ideas are those that are most favourable between rival ideas. These are dependent on the context or socio-cultural background of the learner who is exposed to the new idea. Dominance is usually dictated by overwhelming evidence in support of the new ideas or claims. In a different context the same dominant ideas can be a **Suppressed idea**, for instance, the issues of faith or cultural beliefs will dominate in a cultural context. **Assimilated ideas** are those ideas in the current cognitive structure which are influenced or modified by new ideas to create a more stable mental state. **Emergent ideas** are those ideas that are new and have no rival or opposing ideas (for example, new concepts in school science) in the learners' existing cognitive structure. **Equipollent ideas** are those competing ideas which exert comparably equal intellectual and emotional forces on the learners' cognitive structure (Ogunniyi, 2007a).

CAT suggests that when two or more distinct world views come together in the mind, they either attract or repel each other depending on the context (Ogunniyi and Hewson, 2008). According to Ogunniyi (2007a), CAT 'explains a dialogical framework for resolving the incongruities that normally arises when two (sometimes multiple) competing thought systems (e.g. science, IKS and cultural beliefs, commonsensical, or intuitive notions) are placed side by side as in C2005' (p. 970). When dealing with fermentation, for example, traditional brewing of beer; there are many different methods and processes used with associated rationale which are not normally based on logical or scientifically valid explanations, but based on cultural belief.

Most learners from traditional and cultural backgrounds will be conversant with such cultural beliefs that go beyond the boundaries of logic and hence such beliefs will influence their way of viewing and arguing about the process of traditional beermaking. Understanding of CAT can then enable teachers to understand where learners come from in terms of the way they interpret school science. To interpret some of the learners' views about fermentation as misconceptions can sometimes be unfair since the explanatory models are not the same. Instead of the above, Stears et al. (2003) has suggested that, learners' everyday knowledge of fermentation products and purposes can be introduced 'as a starting point for learning science, as a reference point for thinking about the nature of science, and as a context for applying scientific ideas and skills' (p. 111). CAT can be used as a suitable model to facilitate the contextualization of the new South African Science – IKS curriculum or what is termed RIKA or 'Japanised school science' (Ogunniyi & Ogawa, 2008: 180).The latter consists of science education and 'shizen' (Nature) education. In Japan, the

> ... focus of science education is to enculturate learners into western science while Shizen education focuses on both epistemological, metaphysical and axiological issues such as: encouraging learners to interact with Shizen (Nature) such that they feel and love Shizen (Nature), empathize with Shizen, and commune with Shizen (Ogunniyi & Ogawa, 2008: 180).

To Ogawa, Shizen is seen as a type of cosmology education for Japanese learners and that a cosmology education co-exists unconsciously in Japanese school science. In South Africa IKS is closely related to nature. Our traditional ways of living and our culture reflects the way we view nature. In fact, our ways of living are believed to be controlled by nature and its natural phenomena. Ogunniyi (2007a) argues that C2005 and similar others in the world, have great potential in creating cognitive conflicts among students because of the dualistic nature of those curricula (e.g. science and IKS as in the case of C2005). I believe that, these cognitive conflicts need not be an issue if the nature of the diverse world views is well explicated and commonalities are identified. According to Ogunniyi (2007a), CAT has suggested a mechanism by which the above can occur. It suggests that, there are two types of arguments occurring in the mind of a learner when he/she is trying to make sense of school science. To start with, the learner will first argue with him/herself (intra-argument) and then with others in a conversation (inter-argument). Without this process taking place, rote learning is likely to take place. Virtually in any form of decision making be it at the individual or inter-personal level, dialogical argumentation is a critical element.

2.5.2.1 Contiguity Argumentation Theory (CAT) and Cognitive Co-existence

According to an earlier version of CAT, namely the Contiguity Learning Hypothesis (CLH), the cognitive structure of a learner as well as his/her entire body are involved in the process of learning (Ogunniyi, 1995). Furthermore, as already been highlighted, the distinct world views that are in constant or dynamic state either attract or repel each other depending on a particular context (Ogunniyi, 2008). According to this view, learners have the ability to hold two diametrically opposed world views without experiencing cognitive conflict. This phenomenon which is called 'harmonious dualism' is due to what Ogunniyi (1988) calls 'Contiguous sites'. To explain contiguous sites, the CLH assumes that a learner's cognitive structure consists of three world view schemata: traditional beliefs (IKS), commonsensical or intuitive knowledge and non-intuitive school science views. As deliberated above, the three views are said to be in a dynamic interactive state. As these world views interact, they will seek a point of equilibrium where the cognitive structure settles on a particular verdict. This point of intersection or commonality is the contiguous site of operativity (Ogunniyi, 2008).

As shown earlier, Ogunniyi and Hewson (2008: 146) have contended that the five cognitive categories of the CAT into which conceptions move within a learner's mind or amongst learners normally involve a dynamic process of arguments and dialogues within the learner or among learners. This process involves the mobilization of scientific and/or IKS-based conceptions to attain some form of temporary equilibrium adaptable to a given context. In this regard, learners exposed to a counter-intuitive science curriculum will be forced to engage with the new concepts in form of internal argumentation processes of the mind or through outward argumentation if that opportunity is made available to the learners in the classroom (Ogunniyi & Hewson, 2008; Ogunniyi & Ogawa, 2008).

2.5.3 Applicability of TAP and CAT to the study

The central concern of this study has been to determine the effects of the DAIM on Grade 10 learners' conceptions of fermentation as exemplified in a science and indigenous knowledge curriculum. As stated earlier, teachers who have not been thoroughly trained in understanding the requirements of C2005, they would not be able to understand that infusing two distinct world views in a science classroom would trigger cognitive conflicts in the learners' minds. Those who do would probably not have the necessary instructional approaches to resolve those conflicts while learners proceed in learning science. Science learning by nature is counter-intuitive and generally makes claims that would follow a reason pattern that follows a logical order as in TAP. The TAP enables learners to be able to argue in a constructive way where everyone learns. It is apposite to point out that it is not in every situation that a scientist follows the rules of logic. There are occasions where he/she deploys practical or experiential reasoning, intuition and sometimes serendipity (Ogunniyi, 1986) or what is called happy coincidence.

Using a Dialogical Argumentation Framework such as TAP through the use of appropriate activities and pedagogical strategies would 'promote epistemic, cognitive and social goals as well as enhancing students' conceptual understanding of science '(Simon et al., 2006: 236). Certain areas of school science would definitely by nature of incompatibility or controversy require a different dialogical approach such as CAT which 'explains a dialogical framework for resolving the incongruities that normally arises when two (sometimes multiple) competing thought systems (e.g. science, IKS and cultural beliefs, commonsensical, or intuitive notions) interact together' (Ogunniyi 2007a: 970). CAT in the teaching and learning process 'helps teachers and learners to clear doubts, upgrade current knowledge, acquire new attitude and reasoning skills, gain new insights, make informed decisions and to even change their perspectives' (Ogunniyi, 2008: 11).

Moje et al. (2007) also affirms the above notions and argues that:

> … The discourses of classroom instruction are informed by what teachers and students believe about the nature of knowledge in the discipline … Similarly, the ways that students take up classroom or disciplinary discourses are shaped by the social or everyday discourses they bring to the classroom (Anderson, 2007: 15).

The new curriculum required therefore, teachers who are not just active facilitators of the Science-IKS curriculum, but who are also proactive and better positioned to mediate the curriculum in such a way that learners do not only master the science content, but are aware of limitations of science and IKS. This process will then equip teachers with the necessary skills, values and attitudes, enabling them with the ability of presenting learners with a valid view of science.

2.6 Conclusion

In concluding this chapter, all literature reviewed seem to come to one conclusion that:

1. Science learning is a socially constructed entity.
2. Science and indigenous knowledge systems are premised on different epistemic authorities.
3. Learners from alternate background experience school science differently due to their cultural predispositions.
4. Both thought systems should 'talk' to one another in order to exchange meaning systems so that learning of school science could be enhanced.
5. Although most scholars agree at least implicitly, that argumentation is a better tool for enhancing learners' and teachers' understanding of the NOS and NOIKS, conditions under which borders crossing takes place has not been thoroughly interrogated.

Finally, in order to interrogate claims made by school science, Toulmin (1958) Argumentation Pattern was chosen as more manageable argumentation tool to enhance learners' and teachers' understanding of the nature of science since it was amenable to a deductive-inductive reasoning pattern required for science. TAP helps in regulating and appropriation of scientific claims. While all border crossing theories attempted to explain how learners straddled in between diverse world views, they did not sufficiently explain the conditions and context under which such border crossing takes place. The Contiguity Argumentation Theory (CAT) on the other hand seems to be one learning theory that has attempted to explain a dynamic way in which such incongruities found in the socio-cultural learning paradox can be reconciled where feasible. CAT embraced both world views in attempting to mediate cognitive conflicts that are as a result of different world views and thought systems. In addition to its utility for articulating both systems of thought, it has attempted to 'espouse unequivocally, plausible mechanisms of border crossing' (Ogunniyi, 2008: 3).

According to the present curriculum, fermentation is a topic that is spread throughout many learning areas. In the GET band, Grades 4–9, it is taught in the Technology learning areas, as well as in Natural Science. From Grades 10–12, fermentation is taught mainly in the Life Science (Biology) learning area and its concepts appear here and there in the Physical Science under Natural Cycles. The focus of all science subjects from the General Education and Training (GET – Grades 4–9) band up to Further Education and Training (FET – Grades 10–12) band, is an inclusion of all Learning Outcomes (LOs 1–3) where LO 3 requires the inclusion of IKS into school science. As has been deliberated throughout this chapter and the previous one, it would hardly be possible to achieve such ambitions unless a viable teaching and learning strategy such as the two proposed argumentation frameworks can be explored, modified if needs be and then enacted into the teaching and learning policies.

Although various attempts have been made to elucidate issues surrounding the implementation of a Science – IKS curriculum, locally and elsewhere (e.g. Aikenhead, 1997; Enderstein & Spargo, 1998; Fakudze, 2004; Fleer, 1999; Jegede, 1997; Le Grange, 2004; Ninnes, 2000; Ogunniyi et al., 1995, Ogunniyi, 2007a and b, 2009; Ogunniyi and Ogawa, 2008; Ogunniyi and Hewson, 2008; Onwu, 2009; Sutherland and Dennick, 2002) including the Ministerial NCS Implementation Task Team Final Report (DoE, 2009), more empirical studies are needed to provide additional data and insight in the area. It is hoped that this study would corroborate findings of the few earlier studies as well as provide additional evidence regarding the veracity or otherwise of the theories that have been reviewed in this chapter.

3. Methodology

3.1 Introduction

The present study was concerned with investigating the effectiveness or otherwise of a Dialogical Argumentation Instructional Model (DAIM) on Grade 10 learners' conceptions of fermentation. In the previous chapter, a review of the extant literature was done to explore the various perspectives concerning the issue of integrating science and IKS. In the following sections I shall sketch the procedure used in collecting and analysing the data for the study. I will also present the findings based on preliminary analysis of data. All that is to be presented in this chapter however has been influenced by the nature of the research problem, the theoretical framework underpinning the study and related issues indicated in Chapter 1.

3.1.1 The Research Setting

In attempting to simulate the conditions under which the problem statement applies, the socio-cultural and economic environment that had a mix of learners with parents who had homes in rural and urban areas was chosen. The school in which the study took place is located in one of Cape Town's poorest areas. The school, fictitiously named Culture Secondary School, has Grades 8–12. The school has an average of 44 educators (teachers) and 1500 learners. This gives an average of 34 learners per class. Due to a shortage of qualified science educators and resource related problems, the number of educators allocated to the school and their areas of expertise did not quite correspond to the actual needs of the school. Hence, some of the classes were overcrowded or taught by under-qualified educators or educators whose science background was poor. Consequently, there has been a high failure rate particularly in science at the school.

Also, Culture Secondary School, situated in an informal settlement, is surrounded by three primary schools. Learners from these feeder primary schools come from the same poor community and many of them know each other. The majority of the educators in the school come from relatively more affluent areas. Also, the majority of the learners in the school under study are isiXhosa speakers and a small proportion speaks isiZulu and isiSuthu. Some learners were born in the rural areas of the former homeland areas like Transkei and Ciskei in the Eastern Cape and some were born in Cape Town. As a result of this phenomenon, even those whose parents are isiSuthu or isiZulu speakers; speak isiXhosa fluently. The school has two Muslims educators, one male and one female.

3.1.2 Sample used in the study

Due to the fact that fermentation as a theme runs throughout the different school learning areas such as Life Sciences (Grades 10–12), Physical Science (Grades 10–12), Technology and Natural Science (Grades 8–9), it was not possible to make random sampling since that would have disturbed the time tables of the relevant educators who also taught the same classes. The choice of a Grade 10 class was based on the following reasons:

- The NCS syllabus covering the topic in more detail begins in Grade 10 and the Learning Outcomes are explicitly addressed.
- Grade 10 was more suitable for research in that the learners had left the junior secondary school level and had become more enculturated to the school and free from the demands of the matric examinations. Grade 11 and 12 generally are not easy grades to do research in particularly in an examination-driven education system like that of South Africa.
- The learners have ideas of fermentation from their Natural Science and Technology classes in Grades 8 and 9 as well as from their local communities.
- I had taught Grade 10 for a number years in the same school before taking my new appointment and hence was more familiar with the culture of the school than would have been the case if I had chosen another school.
- The school was not far from where I currently work.

In view of the above, the sample used in the study is a convenient and purposive one in the sense that the choice was informed by the fact that I had taught in the same school in the same grades and learning areas for more than five years and hence had a good prior knowledge of the subjects' socio-cultural environment.

Two groups of Grade 10 intact classes at the Culture Secondary Schools were selected. The two classes were selected on the basis of **comparability** with regard to:

1. The similarities between the two classes since they are taught by the same educator who taught the comparison (C) group (i.e. the group that received an alternative intervention).
2. The C group educator had comparable qualification and teaching experience like mine.
3. All the learners resided in the same community with common or similar socio-cultural and economic backgrounds.
4. Both class groups took Biology and Physical Science as school subjects.

A brief profile of the sample in the study is as follows:

1. There were 21 E group and C group learners who participated in the study with each group having 11 boys and 10 girls respectively.
2. Learners' ages in the E group were from 15 to 17 while those in the C group were from 15 to 19.
3. All the subjects had isiXhosa as a home language with 16 E group and 18 C group learners most comfortable in using isiXhosa.
4. 14 E group learners were born in urban areas as compared to 11 in the C group while those with home in the rural areas were 18 and 20 for the E and C group respectively.
5. 13 E group learners visited their rural home once as year as compared to 10 in the C group while there were 7 learners who visited their rural homes twice a year in both groups.
6. The majority of the subjects in the study subscribe to Christian faith.

A full tabulation and description of the demographic profiles of the learners is presented in the following section.

In line with the two argumentation models underpinning the study as discussed in the chapter however, it is apposite to first examine the biographical data of the learners involved in the study. I will explain later why the two groups of learners came from the same school.

3.2 Research methods

For purposes of this study both quantitative and qualitative research methods were used to collect data. Qualitative data were derived from the learners' written responses to the Conceptions of Fermentation (COFQ), Attitudes to Science Questionnaire (ASQ), Science Achievement Test (SAT) as well as Classroom Observation Schedules (COS) and Focus Group Interviews (FGI). The quantitative data were derived from the learners' performance scores in the Conceptions of Fermentation Questionnaire (COFQ), Attitudes to Science Questionnaires (ASQ) as well as the Science Achievement Test (SAT).

I taught the experimental group (E group) using the Dialogical Argumentation Instructional Model (DAIM) while the comparison group (C group) was handled by another educator using the traditional group lecture/discussion. With the exception of the DAIM, he was provided the learning materials on Science and IKS conceptions of fermentation. The teacher was left to use his normal teaching strategies as per the National Curriculum Statement (NCS) (DoE, 2002) policy document which encourages the integration of IKS into school science. The two groups were exposed to the same bilingual Science Achievement Test (SAT) assessment. I observed the C group educator in order to understand his teaching strategy and to confirm that, what he taught was in line with an integrated Science – IKS agreed upon earlier. Video footage was taken in the E group in order to get a clearer view of how effective or otherwise was the proposed intervention strategy carried out. The video footage also afforded me a better reflective opportunity.

3.2.1 Why the two groups of learners came from the same school

The two groups were two intact Grade 10 classes taught by educator who was assigned in the study to teach the C group. The educator was coached and briefed on all the content to be taught as well as the Science/IKS based approach in presenting the fermentation topics. The C group was chosen purposefully after the plan to use a group in another school did not materialise. No doubt, this crisis created an anomalous setting for me and hence constitutes part of the limitations of this study. But as Ogunniyi (1992) has ably argued, research in the social sciences (including education) are fraught with a congeries of extraneous variables such as history, maturation,

high mortality rate, unpredictability of humans who often act and react to contextual changes, lack of universal theories about human behaviours, problems associated with formulating terms or variables with precise operational definitions etc.

Another limitation connected with the above, is the fact that the C group received intervention after the E group. It was possible that the C group's educator and his learners might have picked up some of the issues covered by the E group. However, since there was a December holiday break between the two group's interventions, it was hoped that, the C group's educator and his learners might have forgotten whatever the E group had done. In addition to this, there was no prior indication that they would be involved in the study. It was also as a result of this that I was also able to sit and observe the C group interventions. This proved useful in giving peace of mind about possible sources of data contamination. My observation of C group enabled me to ascertain how much contamination could have taken place. However, I did not encounter any incidence of such possible contamination. Guidance was also given to C group educator only as far as the content topics and the IKS interfacing with school science was concerned. However, the instructional method was left to the educator without any interference from me.

3.2.1.1 Quantitative research methods

A quantitative research method seeks to establish a causal relationship between the independent and the dependent variable (Ogunniyi, 1996) such as the DAIM and the achievement or attitude or awareness demonstrated by the learners. The instruments used were as follows:

- A pre- and post-test fermentations conceptions' questionnaire that contained the learners' personal details' section, an attitudes to science section and a fermentation conceptions section).
- A Science Achievement Test (SAT) that was administered at the end of the intervention in both groups.

According to Ogunniyi (2009) qualitative research involves the collection of experiential data or reflective data rather than data based on empirical testability or numerical values. While this study was to be largely based on a quantitative design i.e. a quasi-experimental design, the disappointment I referred to earlier prevented me from using the other group as previously planned. I was left with no choice than to pay a greater attention to the qualitative aspect of the study. I have thus chosen to enhance the findings of this study by embracing qualitative research methods as well. This focus afforded me the opportunity to explore aspects of the study that were not easily amenable to quantification as well as the space to make meaningful interpretations which otherwise might be impossible if I had stuck strictly to a quantitative method.

No doubt quantitative methods do have their merits in terms of helping a researcher to make informed decisions in terms of cause-effect relationship between the independent variable and the dependent variable; but in the relation to this study important issues which emanated from the study such as changes in the predispositions or attitudes of the learners would have been missed. In this way I was in a better position to answer questions as to why the proposed intervention was better or less efficient than the status quo method. This adopted method helped me to find out more about underlying issues that might have influenced the findings of the study or why certain learners would perform or under perform on an item. Hence, I used qualitative techniques to probe individual cases for evidence in support of the effectiveness or otherwise of the interventions they received. In addition to this, I was able to interrogate the skills, attitudes and values that the subjects held before and after the intervention. In certain instances I was also able to convert some qualitative observation back to quantitative descriptions. Some authors have suggested that the two paradigms do reinforce each other.

It is obvious from the above scenario, that there is no need to draw a sharp demarcation between quantitative or qualitative research. This perhaps shows the reality of social science research. Alexander cites Nunan (2006) as asserting that:

> […] in practical terms, qualitative and quantitative research are in many respects indistinguishable, and that 'researchers in no way follow the principles of a supposed paradigm without simultaneously assuming methods and values of the alternative paradigms' (Alexander, 2009: 3).

In my study one paradigm's analytical technique was employed in interrogating the other so as to attempt to make meaning of the data or evidence presenting by the other so as to get a better picture of the situation and conditions under study.

3.2.2.2 Basis for the qualitative data gathering procedure

The criteria used for the study was influenced by observing how learners in each group were divided for group work activities. In my observations in the C group, I observed that the educator was dividing his/her learners into groups and giving them different tasks which they reported upon at the end of the particular task. As a result of this observation, learners who became group leaders in each class were selected to be my sample for qualitative analysis. The rationale for this decision was that, group leaders were required to carry and transmit the voices of the group and consequently that of the whole classroom.

Because the experimental group had used structured argumentation lessons which also utilised group work and individual work, I then purposefully decided that my interview samples would consist of group leaders within each group and that a focus group interview would give me a broader view of the learners' socio-cultural background. This decision was also influenced by the fact that the theoretical framework sought to exploit the benefits of structured dialogical argumentation whose outcomes would largely be influenced by group consensus on the topical issue at hand. Views of the groups became important for the purposes of this study because individuals tended to be reserved, but also tended to express their views more freely in a group than as individuals, hence a focus group interview was found to be more appropriate for the study.

This view above is also supported by Fleer who asserts that:

> ... the common practice of interviewing children on a one-to-one basis has also been shown to yield very little indigenous data. However, when children are interviewed as a group, children's responses are much richer and more readily given (Fleer, 1999: 128)

More details about data gathering procedure will be presented later under sub-section 3.4.

3.2.2.3 Qualitative data collection instruments

Quantitative data were derived from the learners' written responses to the Attitudes to the Scientific Reasoning section, the pre- and post-test answers to the conceptions of fermentation questionnaire as well as the learners' written responses in the post intervention science achievement test. All these responses were categorised into the five cognitive categories of Contiguity Argumentation Theory (CAT) framework and in terms of the learners' world views or their language of response to certain key IKS terms. A selected few excerpts of the learners' responses to illustrate certain tendencies were included in the discussions. The learners' verbal responses in the focus group interviews of the two groups were diarised and a summary of what represented the broad or majority voices of the learners was documented.

In terms of class performance, questionnaires and achievement test items were categorised and classified in order to see how the subjects' responses could be categorised in terms of the theoretical framework patterns which guided this study. The pre-test and post-test questionnaire sought to find out what conceptions of fermentation Grade 10 learners held prior and after the intervention. The items expected learners to give explanations or reasons for their answers. These reasons were then analysed in terms quantitative and qualitative descriptions depending on whichever was deemed appropriate.

3.3 Quantitative research design

The purpose of experimental research is to describe 'the consequences of a direct intervention into the *status quo*' (Ogunniyi, 1992: 81). In the context of this study, the intervention was investigated was the DAIM. In terms of the quantitative aspect of the study a quasi-experimental pre-test post-test control group design was used.

O_1	**X**	**O_2**	**(Experimental Group – E)**
O_3		**O_4**	**(Control Group – C)**

O_1 and O_3 represent pre-test observations while O_2 and O_4 represent the post-test observations. X represents the treatment i.e. the DAIM to which the experimental group was exposed. The dashed line between the E group and the C group indicates that, the two groups were intact classes.

3.4 Data collection

Data were collected using:

- Pre-test and post-test questionnaires to investigate Grade 10 learners' attitudes to science and conceptions of fermentation.
- Science Achievement Test (SAT) for purposes of evaluating the intervention treatment that learners were exposed to. Learner worksheets in the both groups in the form of excerpt were collected for qualitative and quantitative analysis.
- Classroom observation schedule were also be used to capture other extraneous and intervening variables.
- A focus group interview schedule was used to get a deeper understanding of the learners' view points and belief systems.
- Video footage of the experimental group was taken.

3.5 Instrumentation

3.5.1 Introduction

The issue of second language learners was of uppermost consideration in the development of the instruments used in the study. As Oyoo has rightly noted:

> An analysis of the language structures in the research instruments used in some studies of possible sources of students' misconceptions in learning science has revealed that language in itself can be a confounding variable in the understanding of science concepts even to those who learn in their first language (Oyoo, 2007: 231).

In my teaching experience in black townships, I have observed that learners even up to Grade 12 have problems expressing themselves in English. As it was in my own experience as a student, I used to try and interpret for myself what was written in English and then try to frame my answers as a translation of what I would have said in my own language which is isiXhosa. This understanding has influenced me in designing the instruments as I knew that the recipients would be isiXhosa speakers who needed to understand what was presented to them. It was hoped that, this would enable me to understand the nature of the underlying conceptions rather than get distracted with their deficiency in English.

The designing of instruments has largely been influenced by my industrial experience in the topic as well as teaching Life Science (Biology) in a secondary school. I have in this regard attempted as much as possible to incorporate this experience in the instrumentation designing. According to McComas (1998), observations are theory laden and the way one observes natural phenomena is guided by one's experience. Whatever the case, however it is totally impossible to be completely objective.

As a person who has grown up in rural areas with both an understanding of traditional practices as well as having industrial brewing experience having worked as a Brewing Overseer, I relied on my experiential knowledge to do translations in support of my quest for knowledge. For me, the important question was to find out the learners' conceptions of brewing and the rationales for their understandings and not their ability to speak the 'language of science', which is supposedly reflecting their conceptual understanding of a scientific topic at hand. It is in this context, that all my instruments are partially bilingual.

3.5.2 Instruments used in this study

As has been highlighted in the data collection section, Table 3.1 categorises all the instruments used for this study. Table 3.1 below provides a summary of the instruments used in the study.

Instruments used in both groups	Measurement scales used and operation sequence for each analysis	Analytical interpretation method
Pre/Post-test Conceptions of Fermentation scale	1. 5-point Strength of Argumentation scale 2. 5-point World View Response classification	1. Quantitative with 2. Qualitative
Pre/Post-test Attitude to Science/IKS scale	5-point CAT categories' sub-scale	Qualitative
Post-intervention Science Achievement Test (SAT) scale	1. 5-point Strength of Argumentation scale Items' levels of skill classification	1. Quantitative 2. Qualitative
Classroom observations	Learner responses and excerpts	Qualitative
Focus group interviews	Learner responses and excerpts	Qualitative

Table 3.1: Instruments and analytic categories of the CAT

3.5.3. Questionnaire

The questionnaire consists of a demographic section, attitudes towards science section as well as the conceptions of fermentation section. The purpose of the questionnaire was to elicit information regarding the learners' views about fermentation processes with specific reference to traditional beer-making as well as associated by-products like traditional bread-making, 'non-alcoholic beverages' and cultured milk or 'amasi'.

The questionnaire is divided into three sections. Section one, two and three are the learners' personal data, attitudes about science and traditional beer content knowledge respectively.

3.5.3.1 Personal Data

For qualitative analysis, the personal data of learners helped in tracking down the subjects for purposes of interview and to obtain correlation between their responses and their bio-data. More details about such bio-data can be found in Appendix A.

3.5.3.2 Attitudes to Science

The learner was asked to read the statement of belief about science and then tick a relevant box which matched his/her belief. Each item was scaled as follows:

Strongly agree – The learner's view matches perfectly with the statement given.

Disagree – The learner's view tends to disagree with the statement given.

Agree – The learner's view tends to side with the statement given.

Strongly disagree – The learner strongly opposes the view expressed.

In addition to the learners' responses, the learners were provided with space to justify their choices. This was to obtain qualitative data that might emerge in their responses and to facilitate the categorizations of such responses in terms of the Contiguity Argumentation Theory (CAT) cognitive categories. It was also hoped that, this would help in giving a better and clearer picture of the learners' views and attitudes to a subject in question. I have left out the option of 'Not sure' as it tends to discourages learners from reasoning hence it becomes the easy way out. This tends to neutralise the learners' views towards a central position. To facilitate the analysis of the subjects' responses in the attitudes to science section, the items have been classified according to the two Science and IKS world view contexts that, the subjects' responses might lean towards. The CAT categorizations of the subjects' responses depended largely on whether the statement of belief leaned towards school science or towards an IKS world view.

Item	Statement of belief	IKSW	SSW
1	Love for school science		X
2	Preference for culturally based science.	X	
3	School knowledge better than knowledge learnt at home.		X
4	Valuing IKS more than science	X	
5	Science is everything (scientism)		X

Key: X denotes a world view context in which the item is classified; IKS world view – IKSW; School Science World view – SSW.

Table 3.2: Classification of Attitudes to Science (ATS) questionnaire

3.5.3.3 Conceptions of Fermentation Questionnaire (COFQ)

This section sought to extract learners' conceptual understanding of the concept of fermentation from mainly a Science – IKS perspective. It was hoped that the information gleaned from this section would help in identifying the science knowledge which might be embedded in IKS. The focus of the questions dealt with the following:

- Fermentation as a concept – What constitutes fermentation?
- Materials used for fermentation – Names of ingredients.
- Nature of key ingredient and its preparation. The correlate of yeast or bacteria.
- The production process steps and duration of step taken.
- The rationale for the use of each material
- Questions relating to cultural beliefs about traditional beer.

More details about the COFQ can be found in Appendix B.

Table 3.3 provides the underlying issues that were considered in analysing the learners' conceptions of fermentation and how these issues played out would be considered in the next chapter.

Item No.	Question seeks to understand whether learners' conceptions are influenced by IK or school science based	CU	PU	SSU
1a.	What notions does the learner have of beer?	X		X
1b.	What notions does the learner have of alcohol?	X		X
1c.	How does the learner associate alcohol to beer or vice versa	X		X
2.	Does the learner know the ingredients used in brewing and what each material is used for?		X	
3.	Does the learner know the step taken when preparing the traditional correlate of yeast, that is, malt or germinated seeds?		X	
4.	Can the learner relate his/her understanding of malt to yeast?	X	X	
5.	Does the learner have an idea of the nature of yeast?	X		
6.	Does the learner know the overall steps taken to make traditional beer as well as duration of each step?		X	
7.	Does the learner know the material/ingredient involved in the formation of alcohol in beer and support his/her answer?	X	X	
8.	Does the learner understand the effects of temperature in a fermentation process?	X	X	
9.	Does the learner know when the fermentation process has taken place and its visible signs?	X	X	
10.	Does the learner know the differences or commonalities between home made beer and that sold commercially?	X	X	X
11.	The learners' views and cultural beliefs about the brewing of traditional beer, including its usefulness or otherwise in society	X	X	X

Key: Conceptual Understanding – CU, Process Understanding – PU and Socio-scientific Understanding – SSU.

Table 3.3: Conceptions of Fermentation Questionnaire (COFQ)

3.5.4 Validation, Reliability and Piloting of instruments

As has been discussed in the previous section, the study has been motivated by a variety of socio-cultural and socio-economic factors on the part of the researcher. The combination of these factors, coupled with the world view theories and research questions to be addressed, the researcher felt that he should design his own instruments. The instruments designed were subjected to validity and reliability tests. Colleagues, teachers and expects were given some of the instruments for their comments. The instruments were piloted in another school fictitiously named, 'Mqokolo Secondary School'. The school was initially planned for the comparison group (C group), but because no teacher was available to administer the intervention, it was used for piloting of the instruments.

Prior to obtaining parametric statistics that would address the research questions, issues of internal consistency and normality of samples had to be ascertained first. It is good practice to first make sure that, the instruments that are used for collecting data are valid otherwise statistical results obtained will also be invalid, hence also unreliable. With regard to normality of a sample, some statistical techniques were based on certain assumptions. These assumptions dictate that prior to the use of that particular statistics, the appropriate assumptions be borne in mind. All parametric statistics are sensitive to how scores of a particular sample are distributed around the sample mean. When low and high scores are equally distributed around the sample mean, then that sample is said to be normal. Kolmogorov-Smirnov normality test is determined for that purpose. It is used to give a measure of how much significant the normality of a particular sample is. In terms of the Kolmogorov-Smirnov statistics, significance values than are greater than 95% or p values less than 0.05, the sample scores are said to be normal. Where the sample scores were not normal, non-parametric statistics were employed (Pallant, 2001; Dawson & Trap, 2004, Ogunniyi, 1992).

Statistical techniques that are not sensitive to how data is spread around the mean are termed, 'non-parametric'. As in the case of the reliability of an instrument, if wrong statistical techniques are used, the results elicited from that particular statistical method will also be invalid. The following tests were done to ensure that any statistical claims made are valid. While no one instrument is reliable under all circumstance or conditions, the Cronbach Alpha values tells how reliable a particular instrument is for general conditions. Likewise, it is very seldom or impossible to get a perfectly normal sample in social science studies. The tests give tolerance values so that the underlying assumptions stipulated by the statistics intended to be used for the quantitative aspect are not significantly violated.

According to Pallant (2001), the Cronbach Alpha coefficient is the most common used indicator of internal consistency or how each item in a scale correlates with each other in terms of the construct that the scale intends to measure. He therefore, recommends that the Cronbach alpha coefficient should be above 0.7. In the above case, 0.7 represents that the instrument concerned should be reliable 7 times out of 10 or 70% reliable. He also adds that the Cronbach alpha coefficient is very sensitive to the number of items within a scale and cited Briggs and Cheek as recommending a mean of the inter-item correlation of 0.2–0.4 in the event that the scale items are under 10 (Pallant, 2001: 11).

3.5.4.1 Pilot test results

After a careful to and fro critiquing of the instruments and proposals at our Friday seminars, the instruments were finally given a go ahead to be piloted. After the piloting stage, all learner responses were categorised according to ordinal scales and captured into the SPSS Statistics programme. The reliability tests were obtained by using the Cronbach alpha reliability values as indicated in the above section. The Conceptions of Fermentation Questionnaire (COFQ) obtained an initial reliability value of less than 0.7 for the original 13 items and through an elimination process provided for by SPSS programme, the number of items achieving a reliability of 0.733 became 8. The items selected for analysis were items, 1a, 1c, 3, 4, 8, 9, 10 and 11. All the 20 items in the Science Achievement Test (SAT) achieved the Cronbach reliability alpha value of 0.791 and hence were all eligible for analysis.

3.5.5 Preliminary data of the main study

Although the reliability test were conducted on a different group in another school, it was felt that, due to the fact that, the two groups were not randomised, all data obtained in the main study needed to be subjected to normality tests so as to decide on whether or not to apply parametric or non-parametric statistics. It was also felt that, the reliability values of the main study data be rechecked. The normality test conducted on all instruments indicated that, sample scores were not normal except for the post-test attitudes to science scores of the experimental group which had a p value of $0.003<0.05$. Dawson and Trap (2004) asserts that:

> Violating the assumptions of normality gives P values that are lower than they should be, making easier to reject the null hypothesis and conclude a difference when none really exists (p. 138).

As a result of the above, I decided to use non-parametric statistics in analysing my data. Table 3.4 below shows the Cronbach alpha reliability coefficients and the corresponding mean inter-item correlations for the pilot are summarised. The table also shows the main study Kolmogorov-Smirnov significances that dictated the use of non-parametric statistics.

Instrument	Cronbach Alpha	Mean inter-item correlation	Normality: Kolmogorov-Smirnov Sig.	No. of valid items
Pre-test Fermentation Conceptions	E – 0.721 C – 0.613	E – 0.378 C – 0.457 (valid)	E: 0.2>0.05 C: 0.2>0.05 (Non-parametric)	8 8
Post-test Fermentation Conceptions	E – 0.605 C – 0.708	E – 0.378 C – 0.457 (valid)	E: 0.2>0.05 C: 0.2>0.05 (Non-parametric)	8 8
Science Achievement Test	E – 0.785 C – 0.707	E – 0.378 C – 0.457 (valid)	E: 0.2>0.05 C: 0.158>0.05 (Non-parametric)	20 20

Table 3.4: Reliability and Normality test results for instruments

3.6 Demographic profile of learners

Section A of the learners' questionnaire collected information relating to their demographic profile. The information was gathered under the assumption that such pieces of information might influence and elucidate the learners' responses to the various instruments. The birth place, the age, gender, rural home background, the first language, language(s) used at home and even the number of books in each home were therefore gathered. The preliminary data on the demographic profiles of the learners are presented later in the chapter rather than in Chapter 4 so as to prevent falling into the error of what Ogunniyi (1992) calls 'the inductive fallacy of pet theory' which might jeopardise distinguishing between the sheep and the goats.

3.6.1 Demographic profiles of learners

Before providing information about how the preliminary data were collected and analysed it seems apposite to indicate that the study involved

both quantitative and qualitative methods. In other words, the two groups were designated as the Experimental Group (E) and the comparison or control group (C) respectively.

Table 3.5 below compares the profile of the learners in both groups in terms of their percentages. This was to further corroborate my assumptions about their comparability of backgrounds. The table shows that, all groups have isiXhosa as the language spoken at home. In the experimental group (E group), 16 learners are comfortable in speaking isiXhosa compared to about 18 learners in the control group (C group). The birth place of the majority of learners in both E (14 learners) and C (11 learners) were born in urban areas whilst 7 learners and 10 learners respectively were born in the rural areas. The table shows that the demographic patterns of the two groups are very similar in all respects

Demographic data	Urban		Rural	
	E	C	E	C
Place of birth	14	11	7	10
Parents' rural home	3	1	18	20
Rural home visits per year	E (N – 21)		C (N – 21)	
Once	13		10	
Twice	7		7	
Thrice	0		1	
Never	1		3	
Duration of stay in weeks	E (N – 21)		C (N – 21)	
1 week	0			2
2 weeks	4			0
3 weeks	5			6
4 weeks	9			10
5 weeks	1			0
6 weeks	1			1
None	1			2

Table 3.5 Demographic profiles of learners in groups E and C

An examination of Table 3.5 above shows that apart from where learners lived at the time of the study, the demographic profiles and the mobility of the E and C learners were similar. The demographic profiles of the learners showed that 14 (66.7%) learners from the E group were born in urban areas as opposed to 10 learners in the C group. Learners born in urban areas would probably be less exposed to activities practised in rural areas. Again, it is seen that 3 (14.3%) learners in the E group have permanent homes in the urban areas as opposed to just 1 (4.76%) in the C group. This implies that, these learners would hardly have reasons to visit the rural areas. For this reason, learners in the control group will probably have an upper hand with regard to traditional information. However, the veracity or otherwise of this claim would be corroborated in Chapter 4.

In terms of rural visits, it can be seen that 13 learners in the E group make one visit per year to the rural areas as opposed to 10 in the C group. With this observation, one would assume that, since more learners in the E group than the control group visits the rural areas, the E group would be more favourably exposed to traditional practices around fermentation. When looking at the table again, it reveals that, although more learners in the E group visited the rural areas, the E group learners' duration of stay was below that of the C group learners. One conclusion that can be drawn from the above is that, learners exposed for a longer period in a particular environment are likely to gather more information than those who were exposed for a shorter period in that same environment. But again, this is merely a conjecture as many other variables might be involved.

According to Jegede (1996), prior knowledge is related to the environment and in fact an aspect of it. He further asserts that, the environment could be geographic, domestic or socio-cultural and that, 'the two are inseparable with the latter creating and nurturing the former' (Jegede, 1996: 10). Table 3.6 below, shows that the number of learners in the experimental group (5) who are not comfortable with isiXhosa is more than those in the control group (3). This observation suggests that, language might also play a role in the learners' ability to expressing themselves in English. But again this must await empirical confirmation. The language preference by the learners also suggests a reason why more of the E group learners than the C group gave answers written in English. The linguistic issues highlighted above all linked to the socio-cultural background of the learners.

Since traditional beer is also brewed in the urban townships, observations regarding items 8 and 9 are common to most learners. Irrespective

of what materials or processes followed in making traditional beer, specific signs and conditions are common.

Item 8 requires the understanding of the effect of temperature on fermentation, while Item 9 requires the understanding of signs by which traditional beer can be observed to have been fully fermented. In understanding the effects of temperature on fermentation, both groups obtained comparable mean rank scores of 21.88 and 21.12. The two were quite close and above 20. For Item 9, the E group was outperformed by the C group. The difference between the two groups' mean ranks for Item 9 was significant with a value of 0.023. The very low performance of the E group in Item 9 is also probably caused by the E groups not being exposed to the rural environments as much as the C group. A look at Table 3.6 below shows that, apart from disparity in age, the two groups had comparable language background. For instance some members of C group were much older than their counterparts in the E group.

	E (experimental)		C (control)	
Home language	IsiXhosa for all 21		IsiXhosa for all 21	
Language most comfortable with	16 in isiXhosa 5 in English		18 in isiXhosa 1 in English 1 in other languages	
Age distribution	15yrs	4	15yrs	1
	16yrs	7	16yrs	2
	17yrs	10	17yrs	7
			18yrs	7
			19yrs	4

Table 3.6 Language and age features of the learners

3.7 Intervention: Dialogical Argumentation Instructional Model (DAIM)

3.7.1 Introduction

The purpose of the intervention is to help learners to be in a position to transfer their traditional knowledge about fermentation into a generalised school science understanding of fermentation, so that they can grow a deeper understanding and interest in the field of biotechnology. As studies have shown, learners from alternate socio-cultural backgrounds experience school science differently than those otherwise exposed. In order to facilitate that 'border crossing' a dialogical teaching and learning approach has been proposed, hence the CAT and TAP frameworks have been infused into the learners' worksheet. The worksheet has been adapted from Toulmin's (1958) Argumentation Pattern and the Contiguity Argumentation Theory by Ogunniyi (1995) has been superimposed over the worksheet by trying to find the sources of the learners' argumentation grounds and even claims made.

3.7.2 Outline of lesson content

The content provided for each study group had common specific learning outcomes that were built into the lessons. The assessments had the following outcomes built into them:

- **Fermentation** as a concept
- Identify **key biological agents** and **ingredients/materials** for fermentation to take place. (Moulds, fungus, yeast, bacteria and substrates such as cereals of sorghum, maize, barley which yield starch and sugars upon which the biological agent work.)
- Application of the knowledge of fermentation in identifying **fermentation food products** and their associated **biological agents** whether commercially available or traditionally prepared.
- Understanding of the process of **traditional beermaking** and compare that with the **industrial beermaking process**.
- Understanding of the concept of an **alcoholic beverage** and the **alcohol** itself.
- Impact of **fermentation** on **society,** the **environment** and **biotechnology.**

Number of period: 12 – 10 hrs contact time

Lesson outline:

The outline of each lesson is shown below:

Lesson 1: (Approx. 50 mins)

- Use of known fermentation products like sour milk, yoghurts, bread, wine and beer, etc. to introduce the concept of fermentation. Use physical features of taste and observations in the making process.

Lesson 2: (Approx. 100 mins – 2 periods)

- Introduce the concept of 'sugars' using carbohydrates (monosaccharides, disaccharides & polysaccharides) and hydrolysis & condensation processes.

Lesson 3: (Approx. 100 mins – 2 periods)

- Introduce biological agents like bacteria, fungus & moulds and their dependency on dead organic matter which results in biochemical conversion of some organic substances.

Lesson 4: (Approx. 200 mins – 4 periods) – can be less

- Follow the process of a fermentation product (e.g. beer (umqombothi), yoghurt/amasi, cheese, and bread) to identify INGREDIENTS/MATERIALS and explain WHICH micro-organisms are used and WHAT they do.

Lesson 5: Consolidation (Approx. 100 mins – 2 periods)

- Comparing the processes FOLLOWED in each step and identify the KEY steps that constitute 'Fermentation'

Lesson 6: Knowledge Integration (Approx. 50 mins – 1 period)

- Discuss the concept of fermentation as a 'Natural Process' and its impact on Society, the Environment and Biotechnology.

3.7.3 Classroom Activities

The task of trying to use dialogical argumentation into classroom practice is enormous. It is a task that seems so obvious and it is easier said than done, because it requires a lot of preparatory work.

Simonneux (2000) have added that, learners do not just learn to argue constructively without any ground work being done by the teacher. He asserts that:

> Our aim must be to help students to identify the criteria and information which support a point of view, theirs as well as those held by others …The rules of the game are established and explained, and the objective of the discussion is made clear: this may be to define an issue, to reach a decision on well-argued grounds, to identify areas of uncertainty or to define the condition or conditions under which a change of view may be considered … students placed in a situation in which they have to argue their case are more likely to acquire the knowledge they call on to do so (p. 904).

In conjunction with the above, I designed activity worksheets that met specific goals and outcomes. These activities were grouped into a number of lessons which I estimated for the duration of the intervention period. The TAP as modified by Erduran (2006) was adopted as an argumentation writing frame for the learners' arguments. Since TAP seems to only cater for deductive and inductive arguments, learners were asked to state the sources of their claims, data and backings. The sources were simplified as 'Personal view knowledge', 'School knowledge' and 'iSintu knowledge'. 'Isintu' relates to the notion of 'ubuntu'. Learners and even African adults when arguing in favour of their cultural background knowledge would argue and say 'isintu sithi', meaning 'our tradition or culture says this or that'. Similarly, 'personal view' refers to 'eyam imbono', which also means, 'in my own personal opinion – not school, not my culture, but I see it this way'. The purposes of including the sources is to assist in utilising the Contiguity Argumentation Theory which asserts that the learners' cognitive structure is made up of 'commonsensical intuitive world view knowledge', 'school science world view knowledge' as well as the 'indigenous knowledge systems world view knowledge'.

3.7.4 Structure of classroom lessons

The learners in the experimental group were presented with fermentation products and also given individual tasks which had questions relating to their observations. The learners had to also redo the same tasks by sitting in groups where they had to discuss and debate their observations giving reasons. The worksheets were developed using the Toulmin Argumentation Pattern (TAP) framework. Learners in the groups had to arrive at a consensus about their views and then present it the whole class.

At the beginning of a lesson each learner was given an activity worksheet and writing frames. The lesson focus and argumentation rules were explained to the learners. Individual learners had to make their claims, give reasons (data) and to give reasons for justifying their data (warrants and backings). Sources of arguments had to be incorporated in the writing frames. A certain time was given to complete that task and thereafter, learners within a group would discuss each other's claims. The educator facilitated the group activities by giving leading questions and hints etcetera. When the group tasks

were completed, a whole class argumentation was started where each group members argued among themselves before reaching consensus of some sort. The teacher recorded the whole class claims, counter claims and rebuttals in the TAP framework writing frame which is activity 2B. Finally, the teacher would do a consolidation of ideas and clarify issues with respect to the content learning outcomes that were envisaged.

3.7.4.1 How a DAIM classroom intervention took place

Lesson 7 dealing with the Socio-Scientific Issue (SSI) of consuming traditional beer versus the consumption of commercial beer was chosen to give a full picture of how a DAIM lesson was undertaken. Since there were five groups with four learners in each group, excerpts from one group will be used to illustrate how individual activities proceeded and how each group discussed each learner's claims and grounds to arrive at a group consensus. Excerpts followed by discussions of what transpired in the DAIM classroom are presented below:

Question: Which one is healthier and safer to drink, home-made amasi (cultured milk) and traditionally prepared beer (umqombothi) or commercially-made amasi as well as commercial beer (like Castle Lager, etc.)? Write your answers as your claims and circle your source of information.
Sources are **A**: Personal views, **B:** School knowledge and **C:** iSintu knowledge (i.e. traditional knowledge).

Note: GP 1.1 denotes learner 1 in group 1, and GP 1.2 denotes learner 2 in group 1 and so on and on.

Individual Activity

Learner: GP 1.1

Claim: 'Home-made amasi and traditional beer are more healthier.' (C)

Reason (evidence): 'Home-made amasi are more healthier because they are not mixed with chemicals, colourants and also traditional beer are good in health.'– (A)

Warrants: 'In home-made amasi there are no chemicals that can be the risk in health or you can't be alegic in it because it is not mixed with different chemicals that can be strong.' – (A)

Learner: GP 1.2

Claim: 'The healthier and safer to drink I choose the home-made and traditionally prepared beer (umqombothi).' – (A)

Reason: 'Home-made amasi and beer (umqombothi) they are good because it have many carbon and starch. They have many oxygen. They have the process of aerobic respiration.' – (A)

Warrants: 'It good to many people because it is not have strong ingredients to make it.' – (A)

Learner: GP 1.3

Claim: 'The healthier and safer to drink is home-made amasi and traditional beer.'

Reason: 'Because traditional beer is not dangerous more than castle and amasi I like this home-made amasi because I see when they do amasi.'

Warrant: 'Home-made amasi I see when I come home with my father on shop. I don't see any one that is do commercially.'

Learner: GP 1.4

Claim: 'Home-made amasi and traditional beer.' – (A)

Reason: 'Because it has natural products like imithombo (malt). It is healthier.' – (A)

Warrant: 'When you do the traditional things you don't use the machines like the technologies things.' – (A)

3.7.4.2 Discussion of group 1 learners' arguments

All four learners in the above group chose traditional beer and cultured milk as their preference, thus their claim that traditional products are better than those commercially made. As reasons or evidence for their claim, all four subjects gave slightly different reasons for their claims. For instance, GP 1.1 gave reasons for choosing traditional beer and amasi and stated that they have no chemicals or colourants that some people might be allergic to while GP 1.2 gave reasons that traditional beer has more starch. In her argument she said that traditional beer have more body which gives people who drink it energy. Learner GP 1.3 gave his reason that, Castle Lager and other commercial beer types where more dangerous because they were very strong and caused people to be drunk. Learner GP 1.4 said that traditional beer was not made with yeast, but with malt or germinated seeds. When all learners in group 1 had exhausted their arguments, they reached a consensus as to what argument they wanted to put forward to other groups. The following is their group argument.

Group 1 claim: Traditional beer and home-made cultured milk were healthier than their commercial alternatives.

Reason: They argued that commercial products have chemicals that some people can be allergic to.

Warrant: They said that sometimes they are not even sure if the amasi they buy from the shops are real dairy products. They seem to be sceptical about commercial products because they say a lot of commercial products are artificial and not pure.

Other groups followed the same procedure that group 1 followed, but had different claims than that of group 1. For instance group 4 reached a consensus that, commercial products are more safer on the basis that they are tested in laboratories by professionally trained people while group 2 rejected traditional products on the basis that modern people do not know how to prepare traditional products safer any more. They argued that the environmental conditions in townships do not allow safer products any more. One learner, GP 2.4 said that milk bought in the shops is different from fresh milk from cows and hence makes very bad amasi from home (because of plastic containers) and that it has a lot of water in it.

In conclusion, not all groups settled for the same claim or gave the same reasons for the same claim, but everyone in each group came out of the discussion having benefited from different perspectives. The educator teaching the E group had to clarify areas of disagreement and gave alternative views using the school science textbook. There were many lessons learnt at the end of the lesson – that there was no one answer to everything, but that a reason or evidence for the claims one makes was very important. They also came out with a sense that Technology employed in commercial food products had a role to play, but was not without any socio-scientific challenges which consumers might not be aware of presently.

3.7.5 Challenges

Introduction of an argumentative classroom in this study was quite a challenging in that the learners were more familiar with the educator-centred approach. Some of the difficulties that emerged were as follows:

- Designing and preparation of worksheets was an extra burden to the lesson plans and consumed more time than was envisaged.
- Worksheets consumed a lot of papers since writing on the board consumed extra time.
- Learners had to be taught to use an argumentation framework, because their arguments were unstructured and did not follow any rules.
- Learners were tempted to copy from each other as they were used to an assessment system that made them believe that there could only be one answer.
- Controlling the learners' discussion and arguments seemed very difficult since the learners were enthusiastic and sometime emotional in the defence of their claims or beliefs.
- Time management for activities seemed to be a problem, because learners took considerable time to complete their given tasks.

3.7.6 Advantages

Although the class was a bit noisy and that not much seemed to have been covered at the end of each lesson, but learners seemed to have:

- Enjoyed the lesson, in that they were able to express themselves freely in the construction of their own knowledge.
- Made sense of the claims as they adduced reasons or the evidence for their beliefs or assertions.
- Understood each others' view points and in so doing clarified their understanding on a particular matter.
- Developed reasoning process skills. This probably helped them in evaluating scientific information.

- Developed an awareness of how argumentative, scientific discourse could be.
- Understood the limitations of their own arguments and thereby developed some relative understanding of NOS and NOIKS.

In summary, the straightforward teaching required a longer period to cover a certain amount of work, but through argumentation learners did not need to memorise anything as multiple opportunities and view points presented themselves in the class where even the slower learner were able to participate in the activities of the class. Every learner's view point was heard and this probably boosted his/her self esteem and developed a robust view of science and IKS. In argumentation, knowledge became integrated into other fields which otherwise could have been impossible. Learners' reasons or pieces of evidence seemed to provide useful examples or subsumers on which other learners hinged or anchored their knowledge.

3.8 Assessment

Assessment has been conducted in the context of evaluating the intervention which has taken place after the initial pre-test questionnaires had been administered. At the end of the intervention, the original pre-test questionnaire was re-administered in order to evaluate the extent of the interventions done on both groups.

In addition to the post-test administration, a Science Achievement Test (SAT) was administered. The focus of the SAT was based on the content outline indicated in section 3.5 above.

3.8.1 Science Achievement Test (SAT)

At the end of the lessons a SAT was administered. The test focused on fermentation, microbial agents and ingredients/materials used in fermentation, the identification of fermentation products and their processes (steps of preparation including, what, how and why questions). The question items as shown in Table 3.7 over were categorised as follows: Conceptual understanding (CU), Recall information (R), Knowledge application (KA) and Process Understanding (PU).

Item	Categorisation of the question	R	CU	PU	KA	SSI
1.	The definition of fermentation?	X				
2.	Naming of some products of fermentation	X				
3	Identifying the kind of biological agent responsible for the type of fermentation product.		X		X	
4	Naming different simple 'sugars' and their sources	X				
5	Understanding the effects of temperature on fermentation		X	X	X	
6	Understanding of the concept of enzymes	X	X			
7	Naming an enzyme and associated substrate	X				
8	Relating the importance of micro-organisms to Society, the Environment and Biotechnology.		X	X	X	
9	Explaining the difference between fermentation and rotting.		X	X		X
10.	Contrasting commercial and home-made fermentation products			X		X
11	Explaining why some fermentation products have little or no alcohol in them		X	X		
12.	Debating the importance or non-importance of alcohol in society		X		X	X
13.	Explaining the concept of aerobic and anaerobic respiration by organisms to explain fermentation	X				
14.	Identifying the IK alternative of yeast	X				
15.	Understanding of starch fermentation processes			X		
16.	Awareness of health risks associated with malting and moulding processes		X	X		X
17a	Associating sourness of some fermented products with acid	X				
17b	Associating bitterness of some products to alcohol	X				
17c	Associating some organisms to acid fermentation	X				
17d	Associating some organisms to alcohol fermentation	X				

X – denotes knowledge or skill(s) required to answer a particular item

Table 3.7: Categorisation of SAT items process skills

3.9 Data analysis

Data derived from the various instruments were analysed in terms of quantitative and qualitative descriptions. The quantitative data set was analysed using SPSS statistics programme which enabled me to re-check the reliability values, normality of data sample scores (to decide whether or not parametric or non-parametric statistics was applicable) as well as the statistics required to answer my research questions. In terms of qualitative analysis, the categorization of learner responses were done in terms of Toulmin's Argumentation Pattern (TAP) as well as the Contiguity Argumentation theory (CAT) descriptions. The TAP categorizations were used mainly in the quantitative analysis while CAT was used largely in the qualitative analysis of the data. The findings were discussed in the context of the extant literature. Similarly, the conclusions reached and their implications for policy, curriculum development and instructional practices were highlighted.

3.10 Ethical considerations

The following steps were undertaken to ensure that the study conformed to the ethical standards laid down by the Senate Research Committee of the University of the Western Cape:

- The principals' permission letters from the two schools was sought.
- The purpose of the study was explained orally and in writing to all participants involved in the study.
- Teachers and learners consent was also sought after.
- All interviews were strictly confidential and a confidentiality letter was written to the schools concerned.
- Learner questionnaires are anonymous.
- Names of schools will be kept anonymous and no information about the schools or learners will be divulged to any person.
- At the end of the study the schools' principal concerned received a summary report of the finding of the study conducted in his/her school.

A major concern that might be raised about the ethics of a study dealing with alcohol production, considering the age of the subjects and the usual negative sentiments about alcohol addiction was well understood and given due attention.

3.10.1 The ethical issue surrounding the production of traditional beer

As already indicated in Chapter 2, the brewing of traditional beer is part of the isiXhosa culture. In this regard, it is the customary for women and girls to do the brewing of the beer. The rationale for brewing traditional beer is for purposes of rituals and participation to such practices that have age restrictions as a way to show respect to the ancestors. The little, if at all any youth might drink; it is purely for symbolic purposes. Even though women and the youth are largely involved in the brewing process, there is scarcely any evidence of young men or youth developing oesophageal cancer. Older women teach young women and girls the process of traditional brewing even in the township but only for ritual purposes.

3.10.2 Commonalities and differences between traditional beer and commercial beer

Traditional beer is generally called, 'umqombothi' even though it is also regarded as an alcoholic beverage. The alcohol percentage in 'umqombothi' is usually around 2 and 3% while the commercial beers range between 4.9% (Lion Lager), 5.8% (Castle Lager), 6.0% (Black Label) and 7.0% for Milk Stout, and between 13–14% for wine. As mentioned above, traditional beer is usually made for ceremonial and ritualistic purposes and in some few instances for selling to adults. On the other hand, commercial beer is more appealing in terms of texture, colours, tastes as well as alcohol volumes.

3.10.3 Precautionary measures taken in lessons

While the lessons on fermentation covered many other related fermentation products like 'amasi – cultured milk', yoghurts, vinegar, bread, traditional beer and commercial beer, dangers relating to the use of alcohol and traditional beer were pointed out clearly. Most of the learners' arguments covered issues of safety of alcohol whether or not it was traditionally or commercial prepared.

Despite connotative and denotative meanings that are attached to alcohol abuse among the youth in South Africa, it was felt that, a study that could ignite a debate around such an issue should be pursued, since most of the products discussed were viewed as current practice. It was also hoped that valuable knowledge could also be gleaned out of the learners' experiences and hence their conceptions of fermentation could have been enhanced. Besides, there were copious opportunities during the study to highlight the reasons why alcohol was a dangerous product for consumption and that other uses for it could be explored. In light of the importance of the process of fermentation in the production of various foods within the isiXhosa community and the emphasis in the new science curriculum, it was felt that valid conceptualisation of the process would provide a platform for the learners to link their IKS with school science and technology.

4. Results and discussion

4.1 Introduction

The purpose of this chapter is to present and discuss the results that emanated from the study. For ease of reference the report and analysis of the results are framed around the following research questions. The research adopted for the analysis was to present first the quantitative data followed by the qualitative data to 'flesh the bone' of quantification so to speak. These findings are then discussed in light of the extant literature.

4.2 Research Question 1: What Science/IKS conceptions of fermentation do Grade 10 learners hold?

In order to address the research questions, the results of the learners' pre-test and post-test conceptions of fermentation were tabulated. The results in Table 4.1, over, were obtained by using the Mann-Whitney U Test for independent samples as well as the Wilcoxon Signed Rank test for comparison of pre-test and post-test results for each group.

An examination of Table 4.1 shows that in the pre-test the E group and C group obtained overall mean rank scores of 20.12 and 22.88 respectively. The two scores are above 20 and thus above half the total of 40 points for the eight items. A no-significance result of **t = -7.58 at p = 0.464** was obtained, also confirming that the two groups were indeed comparable. Except for Item 9, both groups performed comparably on all eight items. A considerable proportion of E group learners seemed not to be aware of the signs of when traditional beer is ready or fermented. Since there was no intervention prior to the pre-test, one conclusion that can be drawn from learners' performance is that, they held prior conceptions of

fermentation. The similarities between the two groups' performances can be assumed to be due to their common socio-cultural environment. There were 4 items in Table 4.1 relating to traditional beer brewing process which were items 3, 4, 8 and 9. These items were interrogated for purposes of gaining additional insight into the learners' prior conceptions about fermentation process. It was noted that, knowledge of about certain items would depend largely on where certain traditional brewing practices are most frequently carried out. As a result, the four items (items 3 and 4 in Table 4.1) were categorised in terms of rural and urban areas.

Practiced in Rural Areas	Mean Rank	Common to Both Urban and Rural	Mean Rank
3. Knowledge of the traditional malting process	E=20.07 C=22.93	8. Understanding of the effects of temperature on fermentation	E=21.88 C=21.12
t-ratio at alpha = 0.05	**-0.763**	t-ratio at alpha = 0.05	**0.282**
4. Knowledge of the IKS alternative of yeast in baking traditional bread	**E=18.93** C=24.07	9. Knowledge of when traditional beer is fully fermented	**E=17.40** C=25.60
t-ratio	**-1.693**	t-ratio	**-6.291**

Alpha level – 0.05, t-critical – 2.021 with df – 40

Table 4.2: Learners' pre-test mean scores on items categorised according to locality

These items required thorough understanding of the ingredients and steps to be followed when making traditional beer. A close look at items 3 and 4, showed that they relate to the tradition beer making process which is only practised in rural areas, because people in the urban areas do not prepare malt for brewing and hence also some learners might not know the isiXhosa name for malt.

However, the locality of the learners did not seem to influence their knowledge of the process of beer making or the ingredients used (Table 4.1). Although most of the learners who used English in their response struggled to express themselves, their answers revealed evidence that they knew what they were talking about. For example, an E group learner, E 16

ITEMS	GP	PRE	POST
All 8 ITEMS	E C	20.12 22.88	27.12 15.88
BTWN GRPS SIG. t-ratios (df–40)/T-crit – 2.025		0.453 -7.58	0.003 7.222
1a. Explaining what beer is	E C	18.76 24.24	24.64 18.36
BTWN GRPS SIG. t-ratios (df–40)/T-crit – 2.025		0.182 -1.36	0.061 2.019
1c. Contrasting beer and alcohol	E C	24.00 19.00	30.79 12.21
BTWN GRPS SIG. t-ratios (df –40)/T-crit – 2.025		0.180 1.364	0.00* 8.198
3. Knowledge of traditional malting process	E C	20.07 22.93	21.45 21.55
BTWN GRPS SIG. t-ratios (df –40)/T-crit – 2.025		0.450 -0.76	1.000 0.00
4. Knowledge of traditional alternative of yeast for bread.	E C	18.93 24.07	25.31 17.69
BTWN GRPS SIG. t-ratios (df –40)/T-crit – 2.025		0.099 -1.69	0.03* 5.862
8. Effects of temperature on fermentation	E C	21.88 21.12	23.40 19.60
BTWN GRPS SIG. t-ratios (df –40)/T-crit – 2.025		0.779 0.282	0.278
9. Knowledge of when traditional beer is ready	E C	17.40 25.60	25.21 17.79
BTWN GRPS SIG. t-ratios (df –40)/T-crit – 2.025		0.023* -6.291	0.03* 5.682
10. Comparing commercial beer and traditional beer	E C	21.74 21.26	29.98 29.02
BTWN GRPS SIG. t-ratios (df –40)/T-crit – 2.025		0.887 -1.43	0.581 0.558
11.Importance or no importance of traditional beer	E C	24.14 18.86	25.67 17.33
BTWN GRPS SIG. t-ratios (df –40)/T-crit – 2.025		0.118 1.559	0.02* 6.001

Table 4.1: Learners' pre-test and post-test conceptions of fermentation

N_MR	P_MR	Ties	Z	WSig.	t-ratio
2 (2) 9.93(7)	11.44 (18) 11.54 (14)	(1) (0)	-3.776 -1.602	0.00* 0.109	-6.598 -1.866
2-tailed T_critical value –2.086 at df – 20					
0 (0) 9.69(8)	8 (15) 8.39(9)	(6) (4)	-3.46 -0.05	0.001* 0.962	-4.787 -1.033
2-tailed T_critical value –2.086 at df – 20					
0 (0) 4.67(3)	8.5 (16) 3.50(4)	(5) (14)	-3.60 0.00	0.00* 1.00	-6.250 -0.025
2-tailed T_critical value –2.086 at df – 20 For pre to post-test analysis per group					
4 (4) 5.75 (6)	7.14 (7) 8.07 (7)	(10) (8)	-1.56 -0.78	0.120 0.067	-1.702 -1.623
2-tailed T_critical value –2.086 at df – 20					
10.5 (1) 5.58 (6)	8.37 (15) 6.50 (5)	(5) (10)	-3.00 -0.05	0.003* 0.964	-3.910 -0.052
2-tailed T_critical value –2.086 at df – 20					
8 (3) 7.25 (4)	8.62 (13) 8.27 (11)	(5) (6)	-2.31 -1.78	0.021* 0.075	-2.461 -1.712
2-tailed T_critical value –2.086 at df – 20					
10.8 (4) 6.7(10)	9.8 (15) 12.4 (7)	(2) (4)	-2.12 -0.49	0.034* 0.625	-2.317 -0.925
2-tailed T_critical value –2.086 at df – 20					
12 (1) 8.2 (5)	9.4 (17) 11.3 (15)	(3) (1)	-3.26 -2.43	0.001* 0.015	-4.962 -4.896
2-tailed T_critical value –2.086 at df – 20					
3.5 (4) 6.5 (7)	5.5 (4) 10.1 (9)	(13) (5)	-0.59 -1.19	0.557 0.230	-0.525 -0.920
2-tailed T_critical value –2.086 at df – 20					

Alpha value is 0.05; * significant difference.

gave an answer to Item 3 (provide the steps taken to prepare 'inkoduso' or malt) as follows:

> **Learner E 16:** 'Take a maize to soak, take out the maize after 3 days, put a maize to make mielie seeds.'

Although learner 16 does not go into detail about where and how to soak the grain, the main thing is that, the learner understood that the malting process required soaking of grain in some water and the storage of such grain in some place for 3 days in order for germination to take place. Most learners in the E group gave such partial answers. Another learner in the C group, for the same item, had the following to say:

> **Learner C24:** 'Utha umbona uwufake esityeni ugalele amanzi uwugqume ngengubo emveni koko umbona untshule umoneke ude wome therefore uwugube umbona' [You take mielies and put it in a dish and pour water and then cover it with a blanket and the mielies germinate after that you spread the mielies until it dries and then you grind it].

The answer of learner C24 is clearer than that of Learner E16 since most of the C group members wrote their answers in isiXhosa. In addition to what E16 has indicated, Learner C24 also highlighted the fact that, the soaked mielies should be kept warm (i.e. covered with blanket) and that when germination is complete, the germinated seeds should be dried before it was ground. A general observation of the learners' scripts in the E group revealed that, their written responses were in English as opposed to those of the C group who frequently did code switching. This could be another reason why the mean rank score of the E group was generally below that of the C group, since their arguments were not very clear. It was only in items 1, 10 and 11 that, the E group's mean rank was slightly higher than that of the C group. Item 1a required that the learners to explain what beer is and items 10 and 11 relate to socio-scientific aspects of the use and consumption of beer.

In Item 4, the learners in both groups were required to show an understanding of the relationship between yeast and malt. Again, the mean rank score of the C group was considerably higher than that of the E group. The mean rank of the E group revealed that, very few of them understood that traditional beer was used to leaven dough instead of yeast in the rural areas. Some learners in the E group simply gave the same answer as yeast; others gave baking powder and vinegar as an answer.

As examples, learner E06 said that, 'the sun is used' as an alternative to yeast when preparing traditional bread. This is a general observation when dough is left covered in a sunny place so that the dough might be raised quicker. In the case of learner E06, temperature or 'heat' was views as the actual ingredient able to raise dough on its own. Many learners held such a misconception. Another learner C25 said that, ' foam of beer' was used for leavening of bread.

For the two items, 3 and 4, discussed above, it is evident that learner C 25 had a relatively clearer idea of what is used for traditional bread making than most of his counterparts. Traditionally, some of the traditional beer is kept aside for bread leavening as well as further brewing requirements. The relatively low mean rank scores of the E group for the rural related items was confirmed by a further analysis of the learners' demographic profiles (See Table 4.1 in section 4.1.2). With few exceptions the demographic profiles of the learners as already indicated in Chapter 3 did not seem to significantly influence the learners' conceptions of the process of traditional beer production.

4.2.1. Summary

Based of the pre-test quantitative data, the two groups were similar in terms of their conceptions of fermentation. Also, the qualitative data did show with few exceptions that learners in both groups were acquainted with the traditional beer-making process. The two data sets also suggest that both groups held to some degree valid scientific/IKS notions about fermentation. Another interesting finding has been the low performance of the E group on certain items. This might be related to where the learners were born, the frequency of their visits to the rural areas, the language they were most comfortable with and the duration of their stay in the rural areas but this must await further empirical confirmation.

In conclusion, since fermentation is a topic that is set for the Grade 12 level and that only very minute pieces of it are covered in the Grades 9 to 11 syllabus, it can be assumed that much of the knowledge they have displayed in the pre-intervention stage is from everyday experience at home and can be termed IKS (Jegede, 1996). All the deliberations above point to one conclusion namely that, in response to research question, the learners at Culture Secondary School did hold to some extant valid scientific conceptions of fermentation pertaining to traditional beer making.

4.3 Research Question 2: What effect does a Dialogical Argumentation Instructional Model (DAIM) have on Grade 10 learners' conceptions of fermentation?

In attempting to address the research question, the pre- and post-tests results were compared (Table 4.2). An examination of Table 4.2 shows that the E group's overall mean rank score (27.12) in the Conceptions of Fermentation Questionnaire (COFQ) was significantly higher as compared to the C group's mean rank score of 15.88. The independent group t-test value gave a significance at t = 7.222; p = 0.003. It was further noted that, the E group's performance from a pre-test mean rank of 20.12 to a post-test mean rank score (27.12) was significant (t = -6.598; p = 0.00) as opposed to that of the C group (t = -1.866; p = 0.109). The results obtained above indicate that, although the E and C group results in the pre-test showed that they both held some valid scientific conceptions of fermentation, the E group's conceptions or understanding of fermentation in the post-intervention stages increased significantly as opposed to the C group. The C group had not improvement as a result of the intervention it was exposed to.

The statistical tests tabulated in Table 4.2 suggest that, the DAIM which the E group was exposed to might have been responsible for the E group outperforming the C group. In fact, the overall mean rank score of the C group had dropped from a pre-test mean rank score of 22.88 to 15.88 in the post-test COFQ. In the following section, the Conceptions of Fermentation (COF) items were further interrogated in terms of their classifications in Table 3.2 as well as how the learners had given their responses in each item.

4.3.1 Learners' pre- and post-test interrogation on the COF questionnaire

Each item was classified either as requiring Conceptual Understanding (CU), Process Understanding (PU), Socio-scientific Understanding or a combination of skills.

In items 1a, 1c, 4, 8, 9 and 10, the E group's post-test scores were significantly higher than their corresponding pre-test scores, namely: t-values of -4.787, -6.250, -3.910, -2.461, -2.317, and p-values of 0.001, 0.00, 0.003, 0.021, 0.034 and 0.001 respectively.

Item	Question seeks to understand whether learners' conceptions are influenced by IK or school science based.	CU	PU	SSU
1a.	Learners' understanding of beer	X		X
1c.	Comparing beer and alcohol with reasons	X		X
3.	Traditional malting preparation process		X	
4.	Can the learner relate his/her understanding of malt to yeast?	X	X	
8.	Does the learner understand the effects of temperature in the beer-making process?	X	X	
9.	Knowledge of when is the beer is fully fermented and its visible signs.	X	X	
10.	Knowledge of the differences and similarities/ commonalities between home made beer and that sold commercially?	X	X	X
11.	Stating with reasons whether the traditional beer have or does not have value in society.	X	X	X

X denotes the knowledge and skills attributes an item is classified under

Table 4.3: Classification of Conceptions of fermentation

According to Table 4.3, the items reveal that, the E group advanced in their conceptions of fermentation from the pre-test stage to the post-test stage in terms process skills, socio-scientific understanding of the issues surrounding fermentation and in particular the production of alcohol. The following excerpts show some of the learners' argumentation shifts from pre- to post-test.

Item 1a: What is your understanding of beer?
Learner E 01 (pre-test): 'Something working in your mind when you drink it'

Learner E 01 (post-test): 'Beer is a alcoholic drink produced by fermentation process.'

The claim made by the learner in the pre-test is supported with a vague reason or evidence in order to explain what beer is. Clearly, the learner had an everyday knowledge of what beer is at the pre-test, but in addition to understanding it as making one drunk the learner's argument seem to have improved at the post-test. The learner developed a conceptual understanding of what an alcoholic beverage is and the process by which it is produced. The learner gave evidence that, beer contained alcohol and that it was produced by fermentation. This means that the learner also developed an understanding of the concept of fermentation and hence could develop more accurate reasons to support her claim. This is some evidence that, DAIM could have assisted the learner to organise her reasoning or evidence for the claims she made.

Learner C 22 (pre-test): 'Beer is alcohol that people drink it'
Learner C 22 (post-test): 'Sisiselo esithi sikwenze unxile' [It is a drink that makes you drunk.]

Although the answer of learner C22 is correct, the learner's claim in the pre-test is that beer is the same thing as alcohol and had no reason to back his claim. The post-test response revealed that the leaner could not give a clear or concrete scientific reason for why beer is a drink that makes one drunk. The learner's reasoning did not reveal anything beyond everyday knowledge about beer. Most of the responses in C group did not show a deep conceptual understanding of what an alcoholic beverage is or its biochemical process. Their arguments were mostly non-oppositional.

Item 4: Yeast is used to raise dough (intlama) in baking bread, what other home made ingredient or material is sometimes used to do the same job and why?

Learner E 15 (pre-test): 'Put the dough in warm or hot place'
Learner E 15 (post-test): 'Umqombothi has yeast inside' [Traditional beer has yeast inside].

This learner's pre-test response shows that, the learner had probably observed parents putting dough in the sun or a warm hut and probably did not know the purpose of the innoculant beer (called 'ivanya' – derived from vino) which is usually mixed with warm water. The learner's pre-test claim was that the dough should be put in a warm place without giving any reason. The post-test response reveals a conceptual understanding of the similarities of yeast and traditional beer which has live yeast cultures. The learner claims that, 'umqombothi' or traditional beer is used as an alternative to yeast in baking bread and the reason for her claim is that traditional beer

has yeast in it. The intervention seems to have entrenched such conceptual understanding among the E group learners. When I examined the responses among learners in the C group, the following was found:

Learner C 24 (pre-test): 'They use baking powder.'
Learner C 24 (post-test): 'It is the sun.'

Learner C 24's pre-test response shows that she did have some ideas about baking of bread at home, but he was not explicit as to whether or not baking powder was home-made. In the post-test she used her everyday knowledge, but could not give reasons why the dough is put in the sun. Most of the learners on this item chose the 'I don't know' option. This can be seen by the fact that, the E group's post-test mean rank scores were significantly higher than those of the C group while the C group's mean rank scores actually decreased at the post-test.

On Item 10 the C group post-test mean score was significantly higher than its pre-test mean score ($t = -4.896$ at $p = 0.015$). Indeed, both groups showed significant improvement from pre- to post-test stage on this item. As in the E group, it seems that the intervention administered to the C group was able to assist the learners in understanding the commonalities between home brewed beer and that brewed industrially. It was further noted that, in items 3 and 11, there was no significant improvement in both groups' pre- post-test performances. For the E group, the t-values were, -1.702, -0.525 with p-values of 0.120, 0.552 whilst for the C group the t-values were, -1.623, -0.920 at $p = 0.067, 0.230$.

In terms of the learners' conceptual understanding of the traditional malting process in Item 3, both groups' pre- and post-test scores on Item 3 indicated that, both groups had a fair conceptual understanding of the malting process and that the intervention administered on both groups did not seem to have influenced their understanding significantly. For both groups in Item 11, the intervention did also not seem to have influenced the learners' views about the value of traditional beer in their communities or society. Both groups had a fair understanding of the value of traditional beer in their pre-test scores (mean scores of 24.14 and 18.86) which were not significantly different ($p = 0.137$). However, their post-test mean rank scores were significantly different ($p = 0.021$). This was born by the fact that, the E group's mean in Item 11 increased slightly (25.67 from 24.14) and the C group decreased slightly from a mean rank of 18.86 to 17.33. As will be discussed in the next section, the tendency of the C group learners to loose their traditional view about the value of traditional beer might be directly linked to the intervention received.

4.3.2 Classroom observations in the control group

To start with, the lesson content for the C groups was the same as that of the E group. The topics for both groups were Science/IKS-based. While I sat in the control group class, I observed that the educator complied with the topics agreed upon. I assisted him by ensuring that all the topics were covered as well with the isiXhosa concepts that he required help with. He also grouped his learners into groups where they worked in pairs. The only major difference I noted was that, the teacher knew the content very well, but struggled to interface IKS into the lesson. As in the experimental group, the teacher introduced some examples as well as some samples of fermented products. The first example he used was 'amasi' which is sour milk or cultured milk. Learners were to discuss how fresh milk turned into sour milk. The introduction was good, but then, as soon as the learners started to enjoy the lesson or discussions, the teacher would go straight into the text book science and take the whole lesson for himself. The teacher would then focus on types of sugars and microorganisms that are the cause for the biochemical changes taking place when milk becomes sour. The pattern of the control group remained the same throughout all the lessons that needed to be covered. The teaching method used in the control group seemed to be only using IKS as an introduction to the school science world or as an ice breaker. The learners who had IKS 'alternative' ways of explaining some of the fermentation concepts were corrected in a way that showed that their way of thinking was 'unscientific'.

4.3.2.1 Classroom conversation between teacher and learners in C group

An example of this situation above is illustrated in the following quotation that I noted during one of the control group's lesson. The lesson was on types of sugars and microorganisms.

Educator: 'Ucinga ukuba yintoni iyisti – sisilwanyana, isityalo okanye ikhemikhali?' [How do you classify yeast – is it an animal, plant or a chemical?]

Learner 1: 'iYisti yikhemikhali tishala.' [Yeast is a chemical, Sir.]

Educator: 'Uyazi njani loonto?' [How do you know that?]

Learner 1: 'Xa uxova isonka tishala, uye ufake iyisti size xa sinyuka isonka iyisti iyi ikhuphe ikhabhon-dayoksayid kwakhona tishal iyisti ingumgubo ofayini xa ithengwa evenkileni.' [When you bake bread, you put yeast in the flour and when the dough rises the yeast gives off carbon dioxide and again teacher, when you buy yeast at the shop you will find that it is a fine powder.]

Educator: 'Uzamile mntanam, ngubani omnye onozama? [Good attempt my child, who else can try?]

Learner 2: 'iYisti yi planti tishala.' [Yeast is a plant teacher].

Educator: 'Kutheni usitsho nje?' [Why do you say that?]

Learner 2: 'Ngaphandle epakethini yayo kukho umzobo wengqolowa.' [On the outside of its packet there is a picture of wheat.]

Educator: 'Very good – yeast is a plant class and not a chemical as the first learner have said.'

Class: (Some learners exclaimed) 'Yiplanti enjani le ingumgubo tishala?' [What kind of a plant is in a powder form?] (Some of the children in class burst into laughter.)

Educator: 'The yeast takes in sugar and breathes out carbon dioxide.'

Learner 3: (Raises his hand) 'Ukuba uthi iyisti yiplanti tishala, kutheni lento ingasiniki ioksijini kodwa isinika ikhabo-dayoksayidi njengezilwanyana?' [If you say yeast is a plant teacher, why does yeast not give us oxygen as plants do, but give off carbon dioxide?]

Educator: (A bit frustrated and confused) 'Bantwana bam … masinga.gqibi ixesha bambani lento ndinixelela yona ngokuba iyisti sisityalo esahlukileyo kwezinye esiphila ngezinto ezifileyo.' [My children … let us not waste time, just hold on to what I tell you, yeast is a plant different from other plants that lives on dead things.]

4.3.2.2 Discussions in the C group

The educator in the above citations got himself into a trap by ignoring his learners' reasoning. All he was concerned about was to hear the right answers. The learners in the C group as has been noted earlier seemed to possess a slightly higher conceptual understanding of how traditional beer was made compared to those in the E group. Many learners in the C group seemed to be quite bright and argumentative. Although Learner 1's answer was not 'correct', the learner made a strong argument, because he noted that yeast produced carbon dioxide and that it was a fine powder sealed in a closed packet. The educator could have capitalised on Learner 1's observations or claims and created a health dialogical environment. Learner 2 was not sure, but only related the picture of wheat on the packet as evidence that yeast is a plant. Although the educator exclaimed, 'Very Good' to learner 2, neither the reason nor the answer given by learner 2 was not correct, because the reason that the picture of wheat outside the packet only indicates that it is used for confectionary purposes. The same picture is also on baking powder which is a chemical and not a 'plant'. The educator also got himself into some trouble by accepting that yeast is a plant and also accepting that it breathes out carbon dioxide as in animals.

The lesson that could be learnt from the above scenario is to never underestimate learners' reasoning abilities. Although the learners did not know the exact nature of yeast and how to categorise it, they had a fair understanding of the basic characteristics of plants, animals and chemicals. The ground was fertile for argumentation using the biotechnology of fermentation to disclose the microscopic nature of the biochemical reactions that underpin Life Sciences (Biology). The educator should have not accepted the answers, but could have continued with interrogating all the reasons given by the learners to the point that a 'dead end' in argumentation was reached.

Hamza & Wickman (2007) in their article about the importance of misconception in learning science have argued that, 'the concept of experience allows us to be generously inclusive in our description of a situation, in that it initially (pre-analytically) assigns all parts of the situation to the same level' (p. 145). In agreement with these authors, I believe that, the process of learning itself involves moving from owning to disowning misconceptions. In simple terms, 'we learn through mistakes or misconceptions'. At this stage the educator of C group could have used IKS-based knowledge about bread mould and mushrooms as examples of the family to which yeast belongs. Adopting the position espoused by Hamza and Wickman for the above situation, he could have treated learning in the classroom as 'the act of giving meaning to events in experience, by making them continuous with prior experience (p. 145). Instead of doing this, he went into deeper science concepts about microorganisms and made the concept of fermentation more abstract. For most of the lessons I observed in the control Group, I generally found that the educator had a good understanding of Life Sciences, but could not organise his

arguments systematically in order to convince his learners. For most of the time his learners were told to just accept whatever he had concluded. Hall and Sampson (2009) have argued that:

> In order to engage students in scientific argumentation as part of the teaching and learning of science, the nature of the typical classroom activity and discourse patterns need to change. In other words, teachers need to do more than tell students about important concepts in science. Teachers also need to.give students opportunities to discuss and critique the reasons offered in support of an idea (p. 16)

The implication of C group educator's stance has the consequence of making learners develop rote learning practices where reason for knowledge becomes less important. In support of my observations, Jegede (1996) has made the following statement regarding how science is taught in Western environments:

> Science knowledge to many students is nothing more than declarative information to be memorized and reproduced when demanded especially during examinations (p. 6).

The focus of the educator in C group was only on getting correct answers perhaps as an arsenal to pass examination questions. This, as Jegede has stated, seems to create a sense in learners' minds that, passing of examinations was more important than trying to understand everything. In line with DAIM whose ultimate intention is that a consensus is reached at the end of a learning experience (Ogunniyi, 2007a), Hamza et al. (2007) have also argued that, activities given to learners contain 'perceived relationships and continuities' and as such the important question was not whether learning had occurred, but rather what direction learning was taking in relation to the actions taken by the learners to deal with the events in the classroom. When learners participate in classroom activities they need empathy and encouragement and that their contributions be valued whether right or wrong as they contribute equally to the learning experience.

I came out with a sense that, perhaps other teachers regard Learning Outcome 3 (LO 3) dealing with IKS as just a means for searching for prior knowledge or what cognitivists would have called 'establishing learners' prior knowledge' before leading them forward (Ausubel, 1968). This observation led me to think, perhaps the notion of a Science/IKS curriculum should be modified and perhaps be called, IKS-contextualised curriculum. This idea can perhaps signal to all stake holders, that there is enough learning opportunities and materials embedded in IKS and that one should only turn to school science where IKS seems to be deficient. My observation led me to revisit what some scholars have said regarding the issue as indicated earlier in Chapter 2.

Onwu and Mosimege (2004) argued that, 'Central to all of this is whether to accord, in the new science curriculum, indigenous and scientific knowledge equal but different status; to view them as derived from competing or complementary world view (p. 1). To speak of equal and yet different status suggest many things. In view of the difficulty at which the C group teacher was unable or unwilling to allow learners to go deeper in arguing about IKS seems to suggest that, introducing IKS into school science is fine, but its scientific status is different. To illustrate this point further, we can think of Language in Education Policy (LiEP) (DoE, 1996) of South Africa, where it is stated that all eleven South African languages are equal and yet had unequal status in terms of their usage in all spheres of life. To probe what Onwu and Mosimege (2004) meant, Onwu (2009) shed some light on the issue. They asserted that, some issues regarding the integration of IKS into the classroom science still remain' murky' (p.22) about the question of what kind of IK should be included into school science. As the above authors have pointed out, it is important for teachers to be able to know when a scientific or an IKS explanation is more appropriate than the other.

The last post-intervention instrument administered to the learners, was a science achievement test. This test was administered a week after the post-test instruments. The purpose of the SAT, sought to evaluate the overall effectiveness or ineffectiveness of the interventions made to the two groups of learners. The scale of the SAT was also sub-scaled to individual levels of argumentation in terms of putting a claim, evidence or support. The scale was designed adapting Toulmins Argumentation Pattern (TAP): 1 – no claim/argument; 2 – Claim and no reason; 3 – Claim with a reason; 4 – Claim a good reason; 5 – Claim with excellent reason. The discussions of the SAT items were done in accordance with the knowledge and skills attributes that each item required from each learner (see Table 3.6 in Chapter 3 for the categorization of the SAT items)

4.3.3 The Science Achievement Test (SAT)

The E group obtained an overall mean score of 27.95 as compared with the C group which obtained an overall mean score of 17.05. The t-test to compare the two groups gave a p-value of 0.001 which means that, the E group's mean rank score was significantly higher than that of the C group. Two sets of tables are provided below. The first table, 4.4i reflects 7 items where there was a significant difference between the two groups and Table 4.4j reflects items where the two groups were comparable. Out of the 7 items indicated in Table 4.4i, below, only one item required recalling of information. Also, out of the 7 items, 6 items required skills ranging from conceptual understanding of fermentation to process understanding, knowledge application and relating the knowledge to socio-scientific issues. This observation suggests that learners exposed to a dialogical instructional method will not only be able to grasp concepts, process understanding and deal with socio-scientific issues on alcohol fermentation, but were also in a position to apply that knowledge when and where it was required. When looking at the other 13 items in which the results of the two groups were not significantly different, it was discovered that the mean score of the experimental group was still higher than that of the C group.

I examined these 13 items and the other items. Table 4.4j, below, show the 13 items where the scores of both groups were comparable. Ten items of the 13 items required only recalling of memory, hence low order questions. Item 8 required a combination of conceptual understanding, process understanding and knowledge application, while Item 15 only required process understanding. The last item was Item 16 which also required a combination of conceptual understanding, process understanding as well as socio-scientific understanding of alcohol fermentation.

The findings based on the SAT scores show that:

- The E group had performed significantly better than the C group on 7 items that required higher order knowledge and reasoning skills. (See Table 4.4i, over)
- In terms of the remaining items on which both groups had performed comparably, it was noted that 10 out the 13 items were low order questions requiring only recalling of information (see Table 4.4j, over).

Common items	Mean Scores	R	CU	PU	KA	SSI	p-values & t-ratios
2. Naming of fermentation products	E = 28.69 C = 14.31	X					p = 0.00 t = 5.823
3. Relating fermented products with certain microorganisms	E = 28.69 C = 14.31		X		X		p = 0.00 t – 4.750
5. Understanding of the effect of temperature on fermentation	E = 27.33 C = 15.67			X	X		p = 0.001 t = 3.629
9. Understanding of the limits of fermentation and its effects on society and environment.	E = 25.33 C = 17.69		X	X		X	p = 0.035 t = 2.360
10. Comparing home-made beer to commercial beer.	E = 28.90 C = 14.10			X		X	p = 0.00 t = 5.066
11. Understanding of why some fermentation products have little or low alcohol content.	E = 26.71 C = 16.29		X	X			p = 0.001 t = 4.074
12.Relating the advantage and dangers of alcohol in society	E = 27.26 C = 15.74		X		X	X	p = 0.002 t = 3.570
Overall performance of the two groups on mean scores out of a total of 35 points.		E = 27.95 C = 15.05				p = 0.001	

X = denotes the knowledge or skill(s) attribute that a particular item requires. T-critical = 2.021, df = 40 at 2-tailed significance values @ alpha = 0.05

Table 4.4i: Learners' conceptions in the Science Achievement Test

Common items	Mean Scores	R	CU	PU	KA	SSI	p-value
1. Understanding of the concept of fermentation	E = 23.71 C = 19.29	X					p=0.426
4. Understanding of sugars and their sources	E = 22.14 C = 20.86	X					p=0.906
6. Understanding of the concept of enzyme	E = 23.50 C = 19.50	X					p=0.123
7. Understanding of link between enzyme and sugar	E = 20.57 C = 22.43	X					p=0.203
8. Understanding of micro-organisms in nature	E = 24.36 C = 18.64		X	X	X		p=0.081
13. Understanding the concept of anaerobic and aerobic fermentation	E = 23.14 C = 19.86	X					p=0.182
14. Understanding the IK of yeast alternative	E = 23.90 C = 19.10	X					p=0.190
15. Understanding of starch fermentation processes	E = 21.95 C = 21.05			X			p=0.864
16. Understanding of the dangerous malting process	E = 23.02 C = 19.98		X	X		X	p=0.485
17a.Understanding of the sour substance in fermented products	E = 23.52 C = 19.48	X					p=0.575
17b. Understanding of the bitter substance in fermented products	E = 24.48 C = 18.52	X					p=0.869
17c. Understanding of the microbial agent making some fermented products sour	E = 22.38 C = 20.52	X					p=0.681
17d. Understanding of the microbial agent making some fermented products bitter	E = 22.36 C = 20.64	X					p=0.684

X = denotes the knowledge or skill(s) attribute that a particular item requires. T = critical = 2.021, df = 40 at 2-tailed significance values @ alpha =0.05

Table 4.4j: Learners' conceptions in the Science Achievement Test (SAT)

4.3.4 Summary for Research Question 2 findings

Based on the findings of the COF questionnaire and the SAT questionnaire, it seemed that the DAIM (compared to traditional teaching used for in the C group) significantly improved the E group's conceptions of fermentation. The findings obtained also showed that, the DAIM did not only improve the E group's performance, but also enhanced their understanding of socio-scientific issues as well as demonstrated high-order reasoning skills. In the light of the above findings, it was concluded that, the DAIM was effective in enhancing Grade 10 learner's conceptions of fermentation.

4.4 Research question 3: Will the awareness and understanding of the NOS and NOIKS of Grade 10 learners exposed to a DAIM be better enhanced than those not so exposed?

In addressing the above question, a 5-item Attitudes to Science (ATS) questionnaire was administered to both groups at both the pre-test and post-test. The five items were in the form of statements that the learners had to place a tick for their agreement or disagreement and then to give supporting reasons for their statement of belief. Their responses to the items were then categorised in terms of IKS World view (IKSW) and School Science Worldview (SSW). The Contiguity Argumentation Theory (CAT) was used to analyse the learners' world views and hence assisted in finding out if the DAIM had actually enhanced the E group's awareness about the Nature of Science (NOS) and Nature of IKS (NOIKS) better than their counterparts in the C group.

As a reminder in Chapter 2, I gave a brief description of CAT's five cognitive categories. The CAT describes probable ways in which ideas move in the mind of an individual from one context to another. Table 4.5 below shows how the categories were used to analyse the qualitative data of this study. The learners' responses to particular items of the Attitudes to Science (ATS) can be assumed to demonstrate what CAT's cognitive category (science or IKS) was dominant, suppressed, assimilated, emergent or co-existing with another cognitive category. Hence, for the purpose of this study, learners' world views on particular items have either been classified as dominant, suppressed, assimilated, emergent or equipollent.

Items	CAT Categories	E group Frequencies		C group Frequencies	
		Pre	Post	Pre	Post
1. Love of School Science: **SSW**	Dominant Suppressed Assimilated Emergent Equipollent	11 2 8 0 0	0 0 2 14 5	15 0 0 0 6	0 1 7 8 5
2. Love of IKS -based Science: **IKSW**	Dominant Suppressed Assimilated Emergent Equipollent	14 3 3 0 1	16 3 0 1 1	16 3 1 0 1	11 7 1 2 0
3. School Science is better than home science: **SSW**	Dominant Suppressed Assimilated Emergent Equipollent	9 8 4 0 0	7 7 0 2 5	5 2 8 0 6	5 5 6 3 2
4. More things are learned about IKS at home than at school	Dominant Suppressed Assimilated Emergent Equipollent	5 3 6 0 7	5 3 1 4 8	1 0 8 0 12	1 3 3 6 8
5. Science can solve all human problems **SSW**	Dominant Suppressed Assimilated Emergent Equipollent	9 0 2 0 10	4 5 1 0 11	2 3 1 0 15	6 5 1 0 9

SSW = School science world view; IKSW = Indigenous Knowledge Systems' world view

Table 4.5: Pre- and post-test of learners' attitudes to science in terms of CAT's cognitive categories

A summary of observation based on the results of the pre- and post-test of the learners' attitudes in terms of CAT's cognitive categories displayed in Table 4.5 above is as follows:

Item 1: I like Life Science (Biology) – dealing with school science world view

The dominant view category: SSW

For both the E and C group, 11 and 15 of the learners' view displayed dominant world views in the pre-test while none of the learners from both groups displays such views in the post-test.

The above observation suggests that, probably the type of intervention that was administered to both groups might have swayed the learners' views regarding the reasons why they love Life Science as a subject. Learners from both groups might have developed alternative ideas about Life Science as a school subject.

The suppressed view category: SSW

- 2 E group learners displaying suppressed views in the pre-test dropped to 0 in the post-test as compared to the C group i.e. no learners displayed a suppressed world view in the pre-test, but one displayed such world view in the post-test.

In terms of the above, the number of learners in both groups that displayed a shift in the suppressed world view category was very small; hence not much can be said or concluded regarding the suppressed view category. One can probably say that the majority of learners from both groups did not seem to display views of being suppressed regarding their love for Life Science. This could means that, whatever changes that might have occurred in their views is due to their own interest or arousal.

The assimilated view category: SSW

- 8 out of 21 E group learners as opposed to zero in the C group displayed assimilated world views at the pre-test. At post-test only 2 E group learners as opposed to 7 C group learners displayed views of being assimilated to school science.

The above shows that, while none of the learners in the post-test displayed dominant views and very few of them displayed suppressed views, nevertheless, some of the learners from the E group (8) who formerly displayed assimilated views were decreasing while the C group learners (7) seemed to be displaying tendencies of being assimilated to school science.

The emergent view category: SSW

- None of the two groups' learners displayed emergent views in the pre-test. 14 E group learners displayed as opposed to 11 in the C group developed such views.

As can be expected, it would be an anomaly for learners to display emergent world view even prior any intervention which they have not been exposed to.

The equipollent view category: SSW

- No E group learners as opposed to 6 C group learners displayed equipollent world views at the pre-test. At the post-test, 5 E group learners displayed such views while the number dropped from 6 to 5 for the C group in the post-test.

As has been discussed under the assimilated category, the number of E group learners displaying an assimilated view tended to decrease and as the above observation show. The E group learners also tended to develop equipollent views. The number of learners in the C group who displayed equipollent views seemed to be dropping whilst the number of those who displayed assimilated views were increasing at post-test.

The trend in Table 4.5 is reflective of probable cause of the significant differences in the fermentation conceptions displayed by E and C learners at the pre- and post-test. In addition, probably the manner in which the C group received its intervention could have subsumed the views of the majority of them into adopting only one scientific world view which is 'western science'.

To highlight the above situation, excerpts for the pre- and post-test responses of some of the E group and C group learners are cited below. The learners' codes and reasoning responses to Item 1 are given for the pre- and post-test. The learners' responses chosen for the ATS questionnaire were of those who were part of the focus group interviews and who were leaders in their groups. This decision was based on the assumption that the focus group learners' might provide more in-depth responses than their counterparts.

Learner Excerpts for Item 1

Learner C 23 Pre-test: (Agree) – 'Life science tend to help us to get information about how earth was formed and the living organisms in it.'

This learner's perceptions about science reflects an equipollent view, because the learner uses 'tend' to somehow suggest that the scientific world view has something to offer or valuable knowledge could be gleaned from science. This suggests further, that because of her awareness about what scientific knowledge brings, the scientific world view exerts a comparably equal force of interest as the learner's prior knowledge or socio-cultural world view.

Learner C 23 Post-test: (Agree) – 'I Understant' (meaning to understand)

In view of the very short response given by this learner, one could only speculate based on the pre-test response. This learner probably means that she loves Life Science because she understands it or improves her understanding about events around her. In the pre-test this learner expressed as sense of interest gaining new information about the universe and living organisms (including animals and plants), but now at the post-test the reason to agree to liking life science is that of 'understanding'. One can only assume that her world view from pre-test to post-test has changed. For this learner, it was not clear how the intervention affected her world view in terms of a school science world view.

Learner E 13 Pre-test: (Strongly Agree) – 'It teaches me about my hidden parts.'

This learner also expresses a view of emergent ideas as I would suppose that the learner when referring to 'hidden parts' means the physiology of the human body.

Learner E 13 Post-test: (Agree) – 'Most of science people help us to lot of things like in this days we have TV in our home because of the people of science.'

This learner acknowledges the value of technology citing the inventions of television. Since the learner has not given other views, one can only assume that at least she has no cultural alternative to television and to that extent the knowledge is emergent. This learner maintained an emergent world view from pre-test to post-test. In terms of the awareness of the NOS that the item required, it was concluded that, the learner was able demonstrate an awareness of where school science fits in, in her personal life.

Item 2: I like science which deals with things in my home or culture - dealing with IKS-based science or knowledge

The dominant view category: IKSW

- 14 E group learners in the pre-test displayed this dominant world views and the number increased to 16 at the post-test while the 16 C group learners displayed this dominant world views at the pre-test but this decreased to 11 at the post-test.

The above observation indicates that about three quarter (16 = 76%) of the E group learners displayed dominant world views at post-test as opposed to about half (11 out 21) C group learners in the post-test with respect to the relevance of science, and of course technology, since they did not make any distinction between the two. Since it was observed in Item 1 (relating to school science world view), that the majority of both groups' (E = 11, C = 15) learners who displayed dominant world views in the pre-test was reduced to zero in the post-test, but now in Item 2 (IKSW), the number of E group learners who maintained a dominant IKS world view increased (14 to 16) while the number of learners in the C group who displayed dominant views in the post-test decreased (16 to 11).

The trend displayed above adds to the results observed for Item 1. While there could be other factors, the major factor could only be attributed to the manner in which each group received intervention. As a conclusion, the E group learners' attitudes to science improved because a considerable number of them expressed an emergent or equipollent views particularly the application of science to their daily lives and culture. Some of C group's attitudes to science seemed to have been swayed. They probably saw science related to their culture as something just to introduce them to school science and thereafter to be abandoned.

To highlight the above findings further, excerpts for the pre- and post-test responses of some of the E and C group learners are cited below.

Learner Excerpts for Item 2: IKSW

Learner E 14 Pre-test: (Strongly Agree) – '*I will learn something that I never here before*.'

This learner strongly believes in home-based science. Cross-checking this with the post-test response of this learner suggests that this learner's view is that of equipollency. I cite the post-test response to support the equipollent view.

Learner E 14 Post-test: (Strongly Agree) – 'It prove us that is a reality life.'

What this learner is probably saying is that he strongly prefers culturally based science because it makes more sense to him i.e. a culturally based science gives him a sense of reality. This to me suggests that the learner does accept school science, but feels and prefers that science be taught in contextualised manner which can make sense to him. The post-test response of this learner seemed to suggest that the manner in which the intervention was administered to her enabled her to maintain an equipollent view regarding Science and IKS-based or culturally based school science.

Learner C 22 Pre-test: (Strongly disagree) – 'They are not true.'
To start with, this learner strongly disagrees that she likes science which deals with her own culture. The learner regards what is practised in her culture as either 'lies' or not scientific. This learner might have understood the term 'science that deals with things in her culture as myth. This could be the case since many learners believe that school science in the only 'true' knowledge.

Learner C 22 Post-test: (Disagree) – 'Kwiculture ayidibani nayo.'
[Meaning: In my culture the two do not mix or are not the same.]

As in the pre-test, it can be seen that this learner still does not see any science in her culture. The learner says that culture and science do not mix. From this learner's response one could assume that this learner's notion of what science is can be described as either as an assimilated or suppressed IKS world view or a dominant scientific world view despite her exposure to the DAIM which stressed a contextualised or what Ogunniyi and Ogawa (2008) call 'indigenized science'.

Item 3: The knowledge I learn from school is better than the knowledge I learn from home – dealing with school science knowledge

The equipollent view category: SSW

- None of the E group learners displayed equipollent views in the pre-test while 5 emerged in the post-test. Contrary to the E group, 6 C group learners who displayed equipollent views in the pre-test dropped to 2 in the post-test.

The above seem to suggest that, during intervention, the E group learners must have gained new knowledge such that 5 of them displayed equipollent while on the other hand the C group's number was decreasing (8 to 6). Although very slight, the above results show that there seemed to be an opposite equipollency world view inclination taken place between the two groups.

The assimilated view: IKSW

- 4 E group learners who displayed assimilated views in the pre-test dropped to 0 in the post-test while the 8 C group learners who displayed assimilated views in the pre-test had been reduced to 6 in the post-test.

The dominant view: IKSW

- The number of E group learners with dominant world views decreased from 9 to 7 from pre- to post-test as opposed to 5 C group learners in the pre- and post-test who did not change.

In terms of the context of the item, the trend indicates that, the dialogical argumentation probably afforded the E group the opportunity to see that school science was not necessarily better than IKS while the teaching strategy on the control group influenced some of them to drift towards an assimilated view in favour of school science being construed as superior to IKS.

Item 4: There are a lot of things that I learn at home that we do not learn at school

The equipollent view category: IKSW

- 7 E group learners in the pre-test as compared to 8 learners in the post-test displayed equipollent world views. 12 C group learners who displayed equipollent world views in the pre-test dropped to 8 in the post-test.

Again, in terms of the above item's IKSW context, the E group learners' with responses that displayed preference for IKS had increased from 7 to 8 as opposed to those in the C group (12 to 8). This seems to suggest that, the interventions received by both groups had opposite effect on the learners, that is, it seems that the intervention given to the E group had a positive effect on the equipollent views of the learners as opposed to the C group intervention which seemed to be having a negative effect on the learners' equipollent view status.

The emergent view category: IKSW

- None of the learners as earlier been stated in the other items displayed emergent world views in the pre-test. Instead, in both groups at post-test stage had the number of learners displaying emergent world view in favour of IKS was increasing, that is, from zero to 4 and 6 for the E group and the C group respectively.

This observation seems to show that both groups had benefited from the Science an IKS based lessons although different teaching and learning strategies were used.

The assimilated view category: IKSW

- 6 E group learners who displayed assimilated views in the pre-test were reduced to 1 in the post-test. Similarly, 8 C group learners who displayed assimilated views in the pre-test were reduced to 3 in the post-test. All in all, both groups learners who exhibited assimilated views in the pre-test dropped by 5 in the post-test.

The suppressed view category: IKSW

- 3 E group learners, formerly displaying suppressed world views at the pre-test remained at 3 in the post-test while the C group learners increased from 0 to 3 in from pre- to post-test respectively.

The above observations seems to suggest that, the number of learners in the E group who displayed assimilated world views remained the same even after the intervention while 3 C group learners displaying such world views emerged in the post-test, suggesting that something in the intervention might have caused that.

The dominant view category: IKSW

- For both groups there was no change from pre- to post-test in the number of learners who displayed dominant views regarding knowledge learnt at home. There was 5 E group and 1 C group learner respectively.

As a summary, the number of E group learners in the dominant, suppressed and equipollent categories has remained the same from pre-test to post-test while only the dominant category remained the same (that is 1) for the C group. In the E group, 5 learners in the pre-test of the assimilated category had changed their world views and some (4 learners) displayed emergent views in the post-test. Similarly with the C group, 5 learners in the pre-test of the assimilated category had changed their world views and some (6 learners) displayed emergent views in the post-test This seems to suggest that due to the IKS-based curricula offered for both groups, all learners saw some value in home-based knowledge, hence the decrease in the number of learners who displayed assimilated views and the increase in the number of learners who displayed emergent views , some learners developed that there was IKS-based knowledge learnt from home that could be valid for school science. This observation indicates that emergent views can develop into any direction, whether into school science or IKS. In the case of Item 4, it seems that both groups were comparable in their preference for home-based knowledge. This finding seems to suggest that, both groups' learners enjoyed the IKS-based curricular lessons.

The equipollent view category: SSW

Item 5: All the problems we have in our communities can be solved through science.

- 10 E group learners displaying equipollent world views at the pre-test maintained their equipollent status in that, their number increased to 11 at the post-test. Contrary to the E group's observation, 15 (about 75%) C group learners displaying equipollent world views at the pre-test dropped to 9 (below 50%) in the post-test.

The observation is suggestive that, the intervention offered to the E group learners might have strengthened their equipollence stance while the C group's equipollence was being stripped off in favour of 'scientism'

The dominant view category: SSW

- Another observation is that, 9 E group learners displaying dominant views about science being a solution for everything in the pre-test had dropped to 4 at the post-test. There were 2 C group learners in the pre-test who subscribed to science as the solution for every human problem as opposed to 6 C group learners in the post-test who displayed a dominant world view.

As has been argued in the previous bullet relating to the equipollent view of the learners in Item 5, the above observation seemed to suggest that, as the number of E group learners with equipollent views were increasing (10 – 11), the number of them who displayed dominant views about 'scientism' in the pre-test were decreasing (9 – 4) as the intervention was progressing. Similarly, the opposite occurred with the C group.

The observations for Item 5 dealing with the hegemony of school science has again shown that, as opposed to the C group, the E group learners' awareness of the NOS and NOIKS was enhanced considerably. Item 5 demonstrates scientism at its best. If science could solve all human problems as the statement seem to suggest then the current public outcry against certain scientific and technological activities as many scholars have pointed out (e.g. see Snively & Corsiglia, 2001; Ogunniyi, 2008) would have been unwarranted.

Analysing learners' written responses proved a bit difficult in that, the learners' responses lacked sufficient grounds in support of their reasoning. Skoumios and Hatzinikita (2009) have added to the above view by asserting that learners usually focus on claims more than reasons in support of their claims. However, the qualitative deliberation seemed to suggest that the DAIM probably steered the E group learners towards equipollent world views while the C group seemed to be developing an assimilative/dominant school science world view.

4.4.1 Focus Group Interviews (FGI)

Two focus group interviews were conducted, one for the experimental group and the other for the control group. The focus group questionnaire sought to find possible relationship between the Science/IKS based content and teaching strategy that each group was subject to. Both groups were asked three identical questions which were given to each group to discuss and then to come to a consensus about how to respond to each question. They had to choose one learner to respond to each question. Since all learners in a focus group were group leaders in the intervention classes, the assumption was that their responses would reflect the voice of the whole group. I wrote down each response given by a particular learner for a particular question. Where clarity was needed the question was rephrased. The Focus Group Interview Questions (FGIQ) and the subjects' responses are presented below.

FGIQ 1: What is your opinion about including IK in the science syllabus at school – do you think that can work?)

Researcher: 'Luthini uluvo lwenu malunga nokufakelwa kolwazi lwemveli kwisilabhasi ye-science esikolweni – ingaba nicinga ukuba inosebenza loonto?'

Learner E14: 'Xa besixoxa ngokwenziwa komqombothi siye safumanisa ukuba ookhokho bethu babenolwazi lwe-science kuba sibone ukuba izinto ebesizifunda azahlukanga kwezo zaziwa ngabazali bethu.' [When we were discussing umqombothi we learned that our ancestors did have knowledge about science, because we found out that the things we were learning in class were not very different from those our parents know at home.]

Learner C23: 'Ewe, sicinga njalo. Xa inofundiswa ngalendlela i-science singatsho nathi cicacelwe msinya, nathi singatsho sizidle nge-khaltsha yethu.' [Yes, we think so. If science can be taught in this way we can understand it easily and in addition we can also pride ourselves with our culture.]

Based on the interviews held with both groups regarding the inclusion of IKS in the curriculum, both groups expressed positive hopes in that, they claimed that their scientific understanding could be enhanced. Both groups also pointed out that, they could be in a position to also pride themselves about their culture being able to contribute to scientific knowledge. Based on some follow-up questions and some responses gleaned, the E group's views seemed fascinated about how scientific the traditional perspective of fermentation they had been exposed to in the intervention lessons really was. On the other hand the C group's response reflected another dimension, that is, the use of IKS made that world view much easier to understand. Equally, they viewed IKS as fascinating and supportive of their scientific world view.

FGIQ 2: Can you explain what you understand about science?

Researcher: 'Ungasicacisela ukuba yintoni i-science?'

Learner E04: 'Sicinga ukuba i-science zizifundo ngezinto ezisingqongileyo.' [We think that science is the study of all things that surround us.]

Follow up by researcher: 'Can you give an example of what you mean by things around us?'

Learner E13: 'Ndingathi tishala, isayensi yilento siyiphilayo okanye ulwazi esilufunda emakhaya nolwazi lwesayensi olusinceda ukuba sikwazi ukwenza izinto zeteknology njalo-njalo.' [What I can say teacher, is that, science is what we live by or the knowledge we learn at home and here at school in science which help to make things of technology.]

Learner C07: 'I-science zizifundo ezisifundisa ngeTeknology, ukuba izinto ezintsha zingenziwa njani.' [Science is any lesson that teaches us about Technology, that is, how new things are made.]

Follow-up question by researcher: 'Xa nisitshoyo, ingaba nithi nokhokho bethu bebeyazi mos i-science?' [When you say so, does it also mean that our ancestors knew or understood science?]

Learner C22: 'Ndingatsho mna tishala, qha mhlawumbi ndingasendithi mhlawumbi uhlobo ebebezenza ngalo izinto bezingekafikeleli kwilevel ye-science esiyifundiswa apha esikolweni.' [I think I can say so teacher, but maybe I can say that, the way they did things was not at the level of science that we learn at school.]

The responses of the E group regarding what science is, seemed to reflect that they view science as the understanding or their experience and knowledge of natural phenomena. Learner E 13 qualified this view by saying that the knowledge at home and in science at school help people to advance in technology. The C group learners on the other hand shed similar ideas regarding technological advancement. In response to the learners' follow-up questions, Learner C 22 seemed to suggest that the scientific level of the indigenous people was much lower than modern science learnt at school. The statement is partly true and partly false. The statement seemed to reflect the sense of hegemonic power of science. The term technology seems to be associated with 'western science' or as a development or improvement of IKS. The control group's responses to question 2 seem to suggest that, had the learners been thoroughly exposed to argumentation about the two seemingly opposite sciences, they probably could have been able to see the commonalities and differences and the roles played by science and IKS in helping them to understand the diverse phenomena they encountered in their life worlds.

In support of the views expressed above, Newton (1999) has argued that, when learners talk, there will be 'opportunity for conjecture, argument and challenge' (p. 554). According to Stears et al. (2003), the use of IKS can both be used 'as starting point for learning science and as a reference point for thinking about the nature of science and a context for applying scientific ideas and skills' (p. 111).

FGIQ 3: What is your opinion about working in groups and group discussions? Do you think it can help you in your understanding of science?

Researcher: Zithini izimvu zenu malunga nokusebenza nize nivavanywe ningamaqela apho iqela lifumana inqaku okanye amanqaku amanye – nicinga ukuba loonto inganinceda ekwazini i-science?'

Learner E02: 'Sicinga ukuba inganceda kakhulu loonto, kuba kwigruphu zethu bekuqala umntu asebenze yedwa size siphinde sidiskhase i-answer zethu size siphume nesigqibo. Loonto yaasenza thina ngabanye kwiigruphu zethu sicacelwe ngakumbi kuba besi-patisipeyita sonke.' [I think that can help us a lot, because in our group a person was working alone first and then we discussed our answers as a group and made a decision. That thing made most of us to understand science better because everyone participated.]

Follow-up question by researcher: 'Anicingi ukuba iyalidla ixesha lephiriyodi loonto?' [Don't you think, doing that takes up a lot of the period time?]

Learner E08: 'Ewe iyalitya ixesha tishala, kuba sasixoxa singayeki ngamanye amaxesha kuba bekukho "sometimes" abanenkani abafuna kuthathwe ezabo kuphela izimvo.' [Yes teacher it takes up a lot of time, because we were sometimes discussing without ceasing because there were others who were stubborn and only wanted only their views to be taken.]

Learner C 10: 'Kurayithi ukusebenza nizigruphu tishala, singatsho nyani siyi-understande i-science. Mna ngokwam ndandiyithanda la-pat yekhaltsha kuba yayixoxisa qha utishala weth wayenqanda.' [It is a right thing to work in groups teacher, we can really understand science. I personally really liked the traditional part of it, because it made us discuss a lot, but our teacher did not want us go far.]

Follow-up question by researcher: 'Utsho ukuthini xa usithi utishala wayeninqanda – okanye wayeninqanda enini?' [What do you mean when you say your teacher stopped you – or in which way and for what did he stop you?]

Learner C 10: 'Eyi! Andazi ukuba ndingathini mhlawumbi omnye angayicacisa lento ndiyivayo – utishala wayethatha ngokuthi liphelile ixesha lengxoxo aqalise ukutitsha ngelixesha sisenemibuzo.' [Eish! I do not know what to say exactly, maybe someone can help me – our teacher would just say the time is up and starts teaching when we still have questions.]

Learner C03: (Hand was up) 'Unyanisile tishala, utishala ebesikhonfuza 'sometimes', ngokuba besithi xa siqala sicinga ukuba sizokuyi-understander into aqalise ajike yonke into athi asizukubhala ezizinto sizixoxayo, ndiqale ndizibuze umbuzo wokuba ebesasixoxisela ntoni kwangaphambili.' [She speaks the truth teacher, our teacher was confusing us sometimes, because when we think we are starting to understand something, he would quickly change everything and tell us that we are not going to be tested on the things we are talking about. This made me think why he allows us to discuss in the first place.]

The key thing reflected about group work in the E group was that, working in groups made each learner participate and that, everyone in the group understood the issue that was discussed. In terms of the follow-up question regarding time wastage, learner E08 asserted that, because of some learners who were stubborn, they found it difficult to easily come to an agreement and hence to complete their task in time.

The C group learners also shared the same view about working and discussing in groups, adding that they enjoyed the IK part in the lessons because it really made them understand the scientific conception of fermentation in both systems of thought. The above assertion has been supported by various examples mentioned by learners in both groups regarding similarities between traditional brewing and industrial brewing. Many learners were actually intrigued by the fact that yeast was a live fungal microorganism which worked in a similar way to moulded maize. The learners in the C group also added that, they were usually stopped by their teacher when they seemed to be going deeper in their discussions. I needed to understand what the learner meant by 'going far'. The learner reflected a sense of frustration, adding that, the teacher would just say 'time up' ignoring whatever questions they might have had. Learner C03, raised her hand indicating that she wanted to say something. The learner supported C10's view and added that, the teacher was sometimes confusing them (class) because as soon as they (class) were beginning to understand something the teacher would abruptly change the topic and tell the class that they were not going to write about the things they were discussing. I did not have enough time to go deeper, but I sensed that, the things they were not going to write were most probably issues relating to IKS which were not covered within the syllabus.

According to Ogunniyi (2007a), the kind of disturbance experienced by the C group learners is in direct contrast with 'the prominence given to dialogues, argumentations, discussions, and group activities in C2005' (p. 968). Other scholars like Erduran (2006) have also argued that, scientific understanding flourish best under argumentative environments. Lederman has been cited by Abd-El-Khalick (2000) as asserting that, 'teachers' conceptions directly transfer into their classroom practices' (p. 669).

Although effort was made to reduce possible barriers that the language of instruction could cause by defining most technical terms in isiXhosa, it might be quite a different matter if the instruction, learning materials and all classroom discourses were done in isiXhosa. However, this was not the focus of the study. However, what can be said at this stage of the study in terms of the learners' conceptions of fermentation it was evidently clear that if all classroom transactions had been done only in English a different result might have emerged. If all had been done in English, the second or third language to some of the learners the positive effects of the DAIM might

have diminished to a significant degree or result in creating a negative world view towards a Science-IKS curriculum (e.g. see Ogunniyi, 2004). Whatever the case may be the importance of the language of instruction is worthy of closer attention in the future.

In concluding the focus group interviews, the following observations were made:

- Both the E and the C groups valued the introduction of IKS in the science.
- Both groups were in favour of argumentation/discursive classrooms when the opportunity was given to them.
- The experimental group echoed the above statement by asserting that group work enabled each and everyone in their class to participate individually as well as in group discussion. They further added that it helped them to clarify issues that were not clear to them.
- The C group also indicated that, if the teacher had allowed them more time to discuss IKS matters, the issue in question might have been understood better than was actually the case. However, they pointed out that unless this approach was properly monitored by the teacher it could result in confusion.

In conclusion, as has been indicated in the findings presented in the previous section, the focus group interviews have again vindicated the view that, while both groups were exposed to Science/IKS-based lessons, the instructional strategies were different and produced different effects with regard to the learners' awareness and understanding of the nature of science and indigenous knowledge systems. On the whole, the E group involved in dialogical argumentation and discursive activities as has been copiously demonstrated in the extant literature (e.g. see Asterhan & Schwarz, 2007 and Newton, 1999; Ogunniyi, 2006) seemed to have benefited in grasping complex ideas, in this case an indigenised science, more than their counterparts in the C group.

4.5 Summary

The three research questions of the study were discussed in terms of argumentation frameworks which underpinned it as well as the research design which was used in pursuit of these questions. The findings in terms of the research questions are listed under the following sections.

4.5.1 Research Question 1: What science/IKS conceptions of fermentation do Grade 10 learners hold?

4.5.1.2 Learners' pre-test conceptions of fermentation

- The results obtained from the two groups' comparison test for independent samples showed that the two groups were statistically equivalent (significance values of 0.464>0.05). When the quantitative results were interrogated qualitatively, the results also showed comparability of two groups in all respects. The conclusion drawn was that the experimental and the control groups held reasonably some valid scientific/indigenous notions of fermentation.

4.5.2 Research Question 2: What effect does a Dialogical Argumentation Instructional Model (DAIM) have on Grade 10 learners' conceptions of fermentation?

4.5.2.1 Findings from Classroom Observations

My observations of both groups focused on what actually happened in each group. It was established that the C group also followed the protocol of the lessons' content in terms of including IKS on all lessons. It was further noted that, the E group was also using some form of group work intertwined with sporadic discussions that tended to create argumentation opportunities. However, from my observation, argumentation as used in the C group seemed to be creating confusion both on the part of the learners and the teacher.

I also observed in terms of the excerpts that were drawn that, it would be unlikely that, the control group learners' conceptions would have been enhanced at the end of the intervention to the extent that was the case in the E group. Instead, the way that IKS was interfaced with science seemed to be confounding classroom discourse rather than pointing the learners to the merits of IKS and associated fermentation methods. The excerpts revealed that the learners' understanding of fermentation was not only getting derailed, but forced them to develop a half-baked understanding of the scientific conception of fermentation. The implication of this for instructional practice is certainly worthy of consideration.

4.5.2.2 Learners' post-test conceptions of Fermentation

The independent sample test with respect to the questionnaire revealed that, the two groups' post-test results were statistically different. A significance value at 0.003<0.05 was obtained.

- The paired samples t-test gave significant values at 0.00 and 0.109 for the E group and C group respectively. These results indicate that the E group's performance from pre-test to post-test in the fermentation conceptions' questions improved significantly as opposed to the C group whose pre- to post-test performance did not improve considerably. The mean of the E group indicated that the post-test score was higher than the pre-test score, hence a better performance. Qualitative interpretations of the learners' conceptions of fermentation suggest that, perhaps an argumentation based instruction was most probably responsible for the differences in the performance of E group learners.
- It was observed that the C group had a slight difference (p = 0.109 which is greater than 0.05), which was insignificant. Obtaining such results was not surprising since both groups received a science/IKS based content which is expected to enhance the learners' fermentation conceptions. Further qualitative interpretations of the quantitative data revealed that, argumentation as an instructional strategy enhanced E group's conceptions about fermentation while a the traditional instructional approach used by E group educator was not as effective in enhancing C learners' conceptions of fermentation compared to that of E group.

4.5.2.3 Learners' post-test performance on the Science Achievement Test (SAT)

This instrument was designed with the intentions to investigate the effects of the interventions on the post-test scores of both study groups. The items were categorised into five main levels of ability i.e. the ability to Recall information (R) , Conceptual understanding (CU), Knowledge Application (KA), Process Understanding (PU) and awareness of Socio-Scientific Issues (SSI). The SAT had 20 items all summing to a total score of 100 since each item was scored on a sub-scale of 5. The sub-scale of the items was designed on the basis of the learners' ability to make and defending the claims they made in their responses to the questions. The results were as follows:

- The mean rank scores of the E group and the C group respectively were 27.95 and 15.05. To find if the difference was significant, a 2-tailed Mann-Whitney Test for independent samples was conducted. The results gave a significance value at 0.001, indicating that the mean ranks of the two groups were statistically different. When exploring every single test item, it was found that the E group received a mean rank higher than that of the C group.
- Seven items in particular in the E group that might have contributed to the disparity between the two groups required skills ranging from conceptual understanding of fermentation to process understanding, knowledge application and relating the knowledge to socio-scientific issues. This observation seems to suggest that the learners exposed to a dialogical instructional method would not only be able to grasp concepts, process understanding and deal with socio-scientific issues, but would also be in a position to apply that knowledge when and where it was required.

When I looked into other 13 items in both groups with similar scores it was evident that though the scores obtained by the E group were relatively higher than that of the C group, the overall difference was not statistically significant and 10 out of the 13 items required only information recalling skills. When the scores of the 13 items were further explored, it was evident that low order or low conceptual understanding questions could be mastered without much argumentation based/discursive teaching and learning approach and hence might not enhance conceptual understanding of fermentation than the normal 'chalk and talk' approach of teaching.

In conclusion, the SAT in addition to the questionnaire, seemed to distinguish the learners exposed to an argumentation instructional approach from those who were exposed to an argumentation instruction teaching approach from those who were exposed to an unsystematic teacher-centred instructional approach.

4.5.3 Research Question 3: Does a Dialogical Argumentation Instructional Model (DAIM) enhance the learners' awareness and understanding of NOS and NOIKS than those not so exposed?

4.5.3.1 Attitudes to science questionnaire in the post-test conditions

While the two groups' pre-test scores were comparable, their post-test results were significantly different. An independent sample t-test gave a significance value at 0.009. This indicated a significant difference between the two groups' attitudes to science.

A further analysis of the two groups' in-between pre-test and post-test in terms of the Contiguity Argumentation Theory (CAT) cognitive categories revealed that the E group learners at the post-test had developed an awareness as to when and where to apply school science knowledge or IKS whereas the C group learners seemed to have been assimilated into school science. The C group's way of viewing science was drifting more towards the negative direction of scientism than the robust direction emancipatory knowledge i.e. owned knowledge and attitudes based on an appreciation and affirmation of one's cultural world view perspective. This observation could be attributed to the fact that the E group as opposed to the C group did not only enjoy a Science/IKS based instruction, but also had opportunities to air their own views. Argumentation in this instance could be seen as entrenching positive attitudes towards science and indigenous knowledge.

Summarising the learners' pre- and post-test responses to Research Question 3 in terms of their attitudes to science:

Both groups' pre-test and post-test responses were analysed in terms of the CAT cognitive categories.

1. The pre-test scores of both groups also indicated that both groups' attitudes to science were fairly good. The number of learners within a particular CAT cognitive category was comparable in both groups.
2. The qualitative in-between groups' comparisons of the pre- and post-test learners' CAT cognitive frequencies revealed that the E group learners were developing more positive attitudes about science and IKS as opposed to the C group learners which whose world view drifted more towards assimilative and dominant scientific world views at the

expense of a world view consonant with their sense of socio-cultural identity.

In conclusion, the above findings seemed to suggest that a Dialogical Argumentation Instructional Model (DAIM) did enhance E group learners' awareness and understanding of, and attitudes towards a Science-IKS curriculum more than was the case of the C group who was exposed to educator-centred instructional methods.

4.5.3.2 Focus group interviews

With respect to the findings and conclusion made from interpreting the voices from the focus group interviews, the conclusions made suggested that, without argumentation or allowing learners to express their views on any matter, it would be difficult if not impossible to enhance learners' awareness of and understanding of, and attitudes towards the NOS/NOIKS.

4.6 Backup statistics for the learners' biographic data

4.6.1 Introduction

Table 4.6, opposite provides the empirical evidence that would confirm or not confirm the issues surrounding learner performances based on gender. In this regard, gender-based independent t-tests within groups and the whole study group were conducted.

The results in Table 4.6 confirmed that, with the exception of the E group ATSQ (p = 0.016), there was no significant difference between the performances of the boys and the girls on all instruments. The results further showed that, irrespective of which group it was or the combination of all groups, the result remained the same (that is, a no significant result was always obtained).

Now we turn to Table 4.7 below for the learners' inter-items performance correlations on the pre-test COF questionnaire including all learners' duration and frequency of visits in the rural areas.

In addition to the above, Spearman rho correlation of the learners' performances on the pre-test COF questionnaire and the frequency and duration of stay in rural areas was also done. Table 4.7, over, provides the results.

Instruments	E group means N = 21, B = 11, G = 10	C group mean N = 21, B = 11, G = 10	Combined group mean N = 42, B = 22, G = 20
Pre-test ATSQ	B = 8.45 G = 13.80	B = 11.68 G = 10.25	B = 19.68 G = 23.50
P-values	0.016 *	0.540	0.255
Pre-test COFQ	B = 11.50 G = 10.45	B = 10.32 G = 11.75	B = 21.89 G = 21.08
P-values	0.697	0.594	0.813
SAT	B = 10.32 B = 11.75	B = 9.14 G = 13.05	B = 19.50 G = 23.70
P-values	0.527	0.148	0.268
Post-test ATSQ	B = 11.82 G = 10.10	B = 13.05 G = 8.75	B = 22.59 G = 20.30
P-values	0.516	0.098	0.538
Post-test COFQ	B = 9.59 G = 12.55	B = 9.86 G = 12.25	B = 19.48 G = 23.73
P-values	0.273	0.376	0.261

B = boys, G = girls, N = number of learners, significance at alpha = 0.05

Table 4.6: Learner performances based on gender differences

The correlations results in Table 4.7, over, revealed the following:

1. There was a significant correlation between the frequencies of and duration of the learners' visits to the rural areas with Item 10, 1a and 9.
2. In the line with the above, it was also observed that Item 10 also had a significant correlation with items 1c, 4, 8 and 11.

The two finding under (2) and (3) indicates that the frequency of the learners' visits to rural areas had a significant influence on learners performed on items, 10, 1c, 4, 8 and 11.

- Item 10 deals with the learners' ability to articulate the difference between traditional beer and commercial or industrial beer.

- Item 1c deals with the learners' understanding of the difference between beer and alcohol.
- Since Item 1c is significantly correlated to Item 1a (with p – 0.015) which deals with the learners' knowledge about the learners' understanding of beer, one can thus conclude that, learners who frequently visit the rural areas would probably be in a better position to understand (Item 1a) what traditional beer was, in addition (Item 1c) be able to differentiate between alcohol and an alcoholic beverage and lastly, (Item 9) know the signs of when beer is fully fermented.
- Item 4 deals with the learners' knowledge about the tradition alternative of yeast which is predominantly used in rural areas.
- Item 8 deals with understanding of the effects of temperature on the fermentation of traditional beer.
- Item 11 deals with the articulation of the value of traditional beer.
- It was also noted, with respect to the duration of the learners' stay in rural areas, that there was a significant correlation between their duration of stay with Item 1a and Item 8 which is also tied to the learners' frequencies of visits to the rural areas

In conclusion, it was found that the frequency and duration of learners' visits to rural areas had a significant effect on the learners' conceptions of fermentation as has been reflected in the learner demographics and Research Question 1 findings.

4.7 Overall summary

This chapter has analysed the findings of this study in relation to the earlier studies in the area. The major findings that have emerged from the interrogation both quantitative and qualitative data are as follows:

- Learners in both study groups held relatively good conceptions of fermentation processes. Their attitudes to attitudes as revealed in the questionnaire indicated that, both groups possessed valid scientific conceptions about fermentation.
- Both groups' pre-test responses to the attitudes questionnaire based on the framework of the Contiguity Argumentation Theory (CAT) revealed that they held largely equipollent views (i.e. Scientific and IKS-based) of fermentation. This means that, they held both the Scientific and the IKS-based views of fermentation in a co-existing manner.

Item		**Freq.**	**Dur.**	**1a**	**1c**	**3**	**4**	**8**	**9**	**10**	**11**
Freq of visits	Corr.	**1**	0.094	0.035	0.126	0.19	0.05	0.136	0.19	**0.35***	0.186
	Sig.		0.276	0.413	0.213	0.105	0.381	0.196	0.113	**0.012**	0.119
Duration of visits	Corr	0.094	**1**	**0.38***	0.237	0.191	0.105	0.03	**0.36***	0.197	0.186
	Sig.	0.276		**0.007**	0.065	0.112	0.253	0.424	**0.009**	0.105	0.119
1a. Understanding of beer	Corr	0.035	**0.38***	**1**	**0.33***	**0.27***	0.099	**0.26***	**0.37***	0.159	0.01
	Sig.	0.413	**0.007**		**0.015**	**0.042**	0.267	**0.05**	**0.008**	0.157	0.472
1c. What is the difference between beer & alcohol?	Corr	0.126	0.237	**0.33***	**1**	0.138	0.010	0.081	0.172	**0.29***	0.023
	Sig.	0.213	0.065	**0.015**		0.192	0.475	0.304	0.138	**0.049**	0.443
3. Traditional malting process.	Corr	0.19	0.191	**0.27***	0.138	**1**	0.006	0.10	0.160	0.016	0.10
	Sig.	0.105	0.112	**0.042**	0.192		0.485	0.258	0.156	0.459	0.256
4. Traditional alternative of yeast?	Corr	0.05	0.105	0.099	0.010	0.006	**1**	0.107	0.128	**0.4****	0.06
	Sig.	0.381	0.253	0.267	0.475	0.485		0.257	0.210	**0.008**	0.350
8. Effect of temperature on beer fermentation	Corr	0.136	0.03	**0.26***	0.081	0.10	0.107	**1**	0.03	**0.5****	0.343
	Sig.	0.196	0.424	**0.05**	0.304	0.258	0.257		0.031	**0.00**	0.013
9. Knowing signs of when beer is fermented	Corr	0.190	**0.36***	**0.37***	0.172	0.160	0.128	0.03	**1**	0.195	0.14
	Sig.	0.113	**0.009**	**0.008**	0.138	0.156	0.210	0.031		0.107	0.185
10. Industrial beer versus traditional beer	Corr	**0.35***	0.197	0.159	**0.29***	0.016	**0.4****	**0.5****	0.195	**1**	**0.5****
	Sig.	**0.012**	0.105	0.157	**0.049**	0.459	**0.008**	**0.00**	0.107		**0.002**
11. Articulating the value of traditional beer	Corr	0.186	0.104	0.01	0.023	0.10	0.06	0.343	0.14	**0.5****	**1**
	Sig.	0.119	0.255	0.472	0.443	0.256	0.350	0.013	0.185	**0.002**	

Corr. – Spearman rho, *significance at alpha – 0.05, **significance at alpha – 0.01

Table 4.7: Correlation of learner performances with their demographic data

- As confirmed in the focus group interview, exposing both groups to Science/IKS lessons seemed to have created much enthusiasm for science in relationship to their IKS-based knowledge.
- Development of a better attitude to science among the E group learners seemed to have enhanced their awareness and understanding of the Nature of Science (NOS) and Nature of IKS (NOIKS) better than those in the C group.
- Learners exposed to a Dialogical Argumentation Instructional Model (DAIM) tended not only to develop better attitudes to science, but also tended to value the science embedded in IKS more than was the case in the C group. This observation was suggested by the fact that the number of learners in this group with equipollent or dualistic views about science increased considerably after the intervention while those in the C group dwindled considerably.
- The science achievement test scores revealed that learners who were exposed to a DAIM tended to develop skills beyond recall and conceptual understanding, but also developed higher order skills such as application and decision-making on socio-scientific issues.
- In certain questionnaire items, it was noted that the learners preferred isiXhosa terms for IKS related concepts than the scientific term. This suggested that, there was a positive relationship between IKS and the learners' home language. Also in the interviews, the learners preferred speaking in their own language. This further suggests that, language might have some effect on the learners' ability in expressing themselves fully. However, this was not the focus of the study as this would require a more comprehensive study than was possible in the study.
- In terms of gender, there were no significant differences between the girls and boys with except with respect to the number of books that they had at home which might influence their overall understanding of fermentation.
- There seemed to be a positive correlation between all learners' performances and the frequency of and duration of the learners' visits and stay in the rural areas during their school holidays.

The above finding seem to agree with a number of other studies regarding the effects of a Dialogical Argumentation Instructional Model (DAIM)

in enhancing learners' awareness and understanding of the NOS (Erduran, 2006; Ogunniyi, 2007a and b; Simon et al., 2006). In terms of the learners' conceptions of fermentation it became clear that language if not carefully integrated in the learners' instructional methodology, could create barrier to learning or result into what Aikenhead calls impossible border crossing (Aikenhead, 1996). Analysis of the world view responses in the learners' attitudes to science responses also concurred with Ogunniyi Contiguity Argumentation Theory (CAT) as cited in Fakudze (2004: 271):

> Border crossing depends to a great extent on the context and interest being served … the type of border crossings that occur, whether it be collateral or multilateral will depend on a host of factors such as the; (1) the consequence of a given response; (2) the interest or satisfaction derived from a learning experience; and (3) the desire to gain mastery over a learning task or the challenge of meeting peer, teacher, parent or societal expectations and so on.

Many instances of the above situations have presented themselves in how individual learners have expressed their views in the attitudes to science questionnaires on socio-scientific issues in the fermentation conceptions questionnaire and the science achievement test. Although learners were allowed to express themselves in isiXhosa, their mother tongue the implication of this mode of classroom discourse would warrant a more comprehensive study. As earlier studies have shown (e.g. (Rollnick, 1994; Rollnick & Rutherford, 1996; Fakudze, 2004), the issue of language of instruction relative to learners' mother tongue would warrant a closer attention in future studies.

It is apposite to state that despite the positive effects of the DAIM in enhancing C group learners' conceptions of fermentation and attitudes towards a Science-IKS curriculum the difficulty in implementing the approach in the current examination driven curriculum education system in South Africa cannot be ignored. Likewise, the time required to train and equip educators with necessary knowledge and skills in this regard must not be overlooked (e.g. see Erduran et al., 2004; Ogunniyi, 2004, 2006, 2007b).

5. Conclusions, implications and recommendations

5.1 Introduction

The central focus of this study was to determine Grade 10 learners' scientific and IKS-based understanding of fermentation. Specifically, the study explored the learners' understanding of fermentation. Also highlighted was the issue of how scientists and indigenous communities produce alcoholic beverages through the process of fermentation. Earlier, the socio-scientific issues surrounding alcoholic abuse in a country where a considerable proportion of underage youths consume a lot of alcohol and thus increasing social problems have also been highlighted and will not be repeated here. Rather, the concern of this chapter is to show the implications of the findings.

5.2 Findings

The major findings in this study were as follows:

- **Learners in both study groups held relatively good conceptions of fermentation processes. Their attitudes to science as revealed in the questionnaire indicated that both groups possessed valid scientific conceptions about fermentation.**

When learners at Culture Secondary School were exposed to a Science and IKS-based conceptions of fermentation question, both study groups' mean scores were above a 50% of the total marks expected. This indicated that, even though the learners had not been exposed to prior fermentation concepts, they had their own existing conceptions. This finding is also in line with the C2005 policy statement, (DOE, 2002) which asserts that even adults have different ways of thinking

for different situations. As Ogunniyi (2004) has argued, learners in Natural Sciences Learning area think in terms of more than one world view. According to Le Grange (2004) learners do possess knowledge that could potentially be 'lost' if not properly harnessed. The question which is begging for an answer is, which of this 'lost' knowledge is valid or invalid and hence worth consideration (Finley, 2009). The challenge posed by these diverse views is that they are underpinned by different epistemic, ontological and axiological beliefs. Some attempts have been made to change learners' indigenous conceptions of various natural phenomena to the scientific world view (e.g. Posner et al., 1982) but these have not resulted in much success. Based on their review of the extant literature in the area, Gunstone and White (2000) have come to the conclusion that:

> The issue now appears to be not of abandonment and the replacement, but one of addition, so that the earlier belief and scientific belief co-exist. The learner's task is to learn the scientific belief, and to become clear about when it is appropriate to apply one belief or the other (p. 298).

In support of the view Ogunsola-Bandele (2009) has stated that science and IKS should be allowed to co-exist. Some studies concerned with blending formal and informal knowledges have come to the conclusion that it is possible to blend formal science and informal science. However, Finley has asked another probing question relating the co-existence of the two world view systems, that is, 'how could we tell when the intersections are productive and when they are valid or not?' (Finley, 2009: 51). In the light of the questions asked by Finley, Onwu (2009) relating to the issue of which aspects of IKS are to be incorporated in the school curriculum as well as Gunstone and White's conclusions based on the extant literature, Ogunsola-Bandele, has added that, 'African science educators have the challenge of searching and providing scientific explanations for traditional African culture, beliefs and superstitions' (p. 56). I concur with Ogunsola-Bandele, because if areas of commonalities can be identified, there might no longer be any concerns about the quality of a Science and IKS-based curriculum. In conclusion, the assertion of the finding that, learners held 'valid' or relatively good conceptions of fermentation were based on the questionnaire which was designed and structured in such a way that it was possible to extract 'scientifically valid' conceptions of fermentation from the learners' pre-test responses.

- **Both groups' pre-test responses to the attitudes questionnaire based on the framework of the Contiguity Argumentation Theory (CAT) revealed though the equipollent world view seemed to be frequently by the learners they demonstrated the different cognitive categories in a variety of ways, (i.e. Scientific and IKS-based) of fermentation. This means that, they held both the Scientific and the IKS-based views of fermentation in a co-existing manner. This corroborates earlier studies in the area (e.g. Aikenhead & Jegede, 1999; Fakudze, 2004; Ogunniyi, 1988, 2004, 2007a &b; Ogunniyi & Hewson, 2008; Ogunniyi & Ogawa, 2008).**

The findings of this study seem to be in agreement with the previous findings where Posner et al. (1982) have pointed out that, learners do hold alternative conceptions that are hard to change in favour of more plausible scientific conceptions. The blessing of the conceptual change theory by Posner and others (e.g. Hewson, 1988; Hewson & Hewson, 1988, 2003). The blessing of the conceptual theory and studies based on it is that researchers became more aware of the importance of prior learning in the teaching-learning process. But as already indicated by Gunstone and White (2000) changing or replacing learners' beliefs with the scientific belief is almost nigh impossible using the theory in the strictest sense. In addition, Jegede (1996) has also warned that, if care is not taken regarding learners' pre-conceptions which he calls 'mysteries', they 'are capable of causing blockage to any scientific knowledge the child might acquire as a result of schooling' (p. 18).

It can be argued that learners' willingness to learn is determined by interest at stake and that a conducive learning environment might help mediate the learning process from the known to the unknown. In the case of learners holding dualistic or equipollent world views, the Contiguity Argumentation Theory (Ogunniyi, 2007) seems to have elucidated the process of how conceptions flow within learners' cognitive structures. Rollnick and Rutherford (1996) have also alluded to the fact that, 'pupils utilise two separate knowledge systems in order to achieve this and operate happily in these two paradigms' (p. 91). However, most studies dealing with border crossing or dualistic world views seem not to have given an satisfactory explanation of how learners hold equipollent or dualistic world views.

According to Ogunniyi (2009), 'the context of a particular discourse plays an important role in the amount or intensity of emotional arousal experienced by the participants in such a discourse' (p. 3), thus equipollency

of the learners' world views has been as a result of two competing world views exerting equal forces on the cognitive structure of an individual. The implication for instructional purposes is that, conducing learning environments such as the DAIM should be used in order to mediate between the two diverse world views so that, learners can be in a position to recognise and utilise whichever world view is appropriate at a particular time.

- **As confirmed in the focus group interview, exposing both groups to Science/IKS lessons seemed to have created much enthusiasm for science in relationship to their IKS-based knowledge.**

In the light of C2005 which calls for the integration of IKS with school science, it is imperative that strategies which promote the interfacing of the two world views (Fleer, 1999) be adopted for teaching and learning. Chiappetta et al. (1998) have argued that, since science occurred in a cultural context, 'the culture of a science classroom is an unfamiliar one' (p. 51). For culturally diverse learners to be successful, 'school science must be related to their home culture' (ibid.).

- **Development of a better attitude to science among the E group learners seemed to have enhanced their awareness and understanding of the Nature of Science (NOS) and Nature of IKS (NOIKS) and as opposed to the C group.**

It is argued that, the learning process entails the process of internal reasoning, arguing with one's self and even to externalise one's views (Ogunniyi, 2007a; Ogunniyi and Hewson, 2008). It has also been argued that, science as product is not enough in order for its recipients to develop scientific literacy. Erduran (2006) have argued that science is a human construct and hence the basis upon which science is defined needs to be well understood. Without the learners' world view and the science world view being able to 'speak' together (Fleer, 1999; Jegede, 1996), learners will not be in a position to understand the limitation of their own world views and those of the school science world view. Although both the E group and C group were exposed to a series of learner friendly Science/IKS fermentation lessons, it became apparent that, if a dialogical space was not created for learners, learners would not benefit much no matter how good a lesson was.

As has been evidenced in the classroom observations, focus group interviews as well as the E group's performance versus that of the C group on all instruments, it was clear that the E group learners who were exposed to a DAIM were able to participate fully in all activities, argue their points of view without any fear of being wrong because the setting was not one of assessment which carry a punitive connotation. As opposed to the E group, the C group learners were constantly harassed by their teacher regarding right and wrong answers and that they were psychologically reminded of the 'importance' of school science as opposed to IKS. What the C group teacher believed and practised seemed to have caused a negative shift among his learners (Ogunniyi et al., 1995). As a result, the C group learners were made to believe that, scientific facts were very important and that probably must have assimilated their own world view thought systems to a point of not being able to know when and where to apply school science or IKS.

The C groups' experiences as Jegede (1996) have warned, might have triggered blockages such that the learners developed a sense of confusion (Jegede and Aikenhead, 1999), while the E group learner probably understood everything taught in the lessons 'without necessarily believing any of them' (Jegede, 1997: 11). The implication of the above arguments in relation to instructional practice, is that, a DAIM is central to learners' awareness and understanding of the NOS/NOIKS (Ogunniyi, 2007a and b; Abd-El-Khalick, 2000).

- **Learners exposed to a Dialogical Argumentation Instructional Model (DAIM) tended not only to develop better attitudes to science, but also tended to value the science embedded in IKS more (e.g. see Newton, 1999). This observation was suggested by the fact that the number of learners in this group with equipollent or dualistic views about science increased considerably after the intervention while those in the C group dwindled considerably.**

Learning of science from socio-cultural perspective is deemed to be context dependent, that is, learners from diverse cultural background will experience science learning differently (Stears et al., 2003). In view of learners coming from diverse world view, some border crossing models have been proposed (Jegede and Aikenhead, 1999) to explain why non-Western and Western learners experience culturally related cognitive dissonances. The DAIM that the E group learners were exposed to, enabled harmonious dualism where the E group learners could hold two diametrically opposed world views without experiencing cognitive conflicts (Ogunniyi and Ogawa, 2008). According to Ogunniyi (2008), the two diverse views are in constant contact and changes in accordance with a more stable and adaptable context at any given stage. This

explains why the E group learners as opposed to the C group learners tended to develop better attitudes towards school science while at the same time developing more appreciation for science embedded in IKS.

The implication for instruction of the scenarios above is obvious. Conceptual change theory requires a dramatic restructuring of the existing knowledge base (Feltham & Downs, 2002) since the existing knowledge base is regarded as misconceptions that are viewed as potential stumbling blocks for the 'new' scientific knowledge that the learners need to assimilate. The weakness of the conceptual change theory perhaps, as has been pointed in the extant literature (Ogunniyi and Hewson, 2008), is its assumption that learners would easily abandon their entrenched beliefs overnight as a result of a series of well formulated and implemented classroom instructions. Again as a review by Gunstone and White (2000) has shown:

- **Making the scientists' version intelligible and plausible caused no problem; teaching had long been directed at those matters. The difficulties seemed to be in bringing about dissatisfaction with existing beliefs, and in obtaining acceptance that change to the scientists' view would be fruitful in wider context than just learning to pass examinations (p. 298).**

The finding seem to confirm other related studies, that learners as well as adults hold multiple world view presuppositions and that, teaching and learning should seek to harness these world views so that they can live side by side.

- **The science achievement test scores revealed that learners who were exposed to a DAIM tended to develop skills beyond recall and conceptual understanding, but also developed higher order skills such as application and decision-making on socio-scientific issues.**

According to C2005 policy statement (DOE, 2002), four science focus areas or Learning Outcomes (LOs) have been outlined. In terms of the above finding in relation to the envisaged LOs by the policy document, it is evident that the E group learners seemed to have developed a wide range of skills. LO 1 states the following:

> Problem solving is central to the teaching and learning of Physical Sciences. Higher order thinking and problem solving skills are required to meet the demands of the labour market and for active citizenship within communities with increasingly complex technological, environmental and societal problems (DoE, 2002:12)

The above quote does concur with the findings where the E group learners developed higher order skills and problem solving/application skills. Learning outcome 4 requires that learner should develop decision-making skills while LO 2 requires that learners apply knowledge in socially and environmentally responsible ways.

- **In certain questionnaire items, it was noted that the learners preferred isiXhosa terms for IKS related concepts than the scientific term. This suggested that, there was a positive relationship between IKS and the learners' home language. Also in the interviews, the learners preferred speaking in their own language. This further suggests that, language might have some effect on the learners' ability in expressing themselves fully.**

Sutherland and Dennick (2002) have argued that, learners for whom English is a second language, conveyance of scientific explanations is influenced by conventions of discourse in their mother tongue (isiXhosa in this study). In terms of extant literature, they concurred that, 'The literature supports the view that teaching science in English to some non-Western groups of students does not provide them with equal access to information (Sutherland and Dennick, 2002: 5). Rollnick and Rutherford (1996) have noted that, 'it is important to realise that knowledge of second language can be an advantage in concept acquisition as it helps to see different representations of the same idea' (p. 93). The above quotation affirms the above finding.

The study conducted by Rollnick and Rutherford (1996) was on primary Swazi trainee teachers and the purpose of the study was to investigate how languages were used in the classroom and whether the choice of language, English, SiSwati or both affected the remediation of alternative conceptions and the acquisition of scientific conceptions. The findings obtained indicated that the use of isiSwati served several functions such as, 1. Invoicing of alternative conceptions, in clarifying of concepts, in elimination of misconceptions and in formulating of new ideas. The conclusions arrived at by the authors was that, there were no problems experienced with the absence of scientific words in isiSwati since the students simply used English words in conversations. They cautioned however, that the pitfall could be that, when alternative misconceptions are posed in isiSwati and a right answer was formulated in English, the teacher might not recognise that. The implication of the findings obtained by Rollnick and Rutherford suggest that, perhaps a 'systematic code switching' practice where certain key terms or concepts are translated as has been the case in this study, should be adopted. Learners were free to flow in-between the two languages, English and IsiXhosa. As has been argued in Chapter 2, language should not be seen as a handicap, but as a resource. Minority languages like IKS need to be seen as resources. Similar studies promoting the value of bilingualism in the understanding of scientific language (Kearsey and Turner, 1999: 1048) have come to similar conclusions and added that, 'There is value to be gained in terms of scientific learning if bilingualism is treated as a resource in the classroom and if bicultural links are established and encouraged in the classroom' (see also Setati, 2002).

In support of the above Naidoo and Savage, cited in Ogunniyi's prepublication *Book 1: Nature of Science*, argue that, 'a better use of **existing resources**' is needed in science education which should:

> ... be cheap enough for all educational institutions, thus promoting equity. Be more soundly based on current learning theories, thus promoting understanding rather than rote learning. Empower students to contribute better to personal, community and national development and participate more actively in the democratic process. Present a more accurate view of science than traditional courses portray. (Ogunniyi, 2008: 94)

- **In terms of gender, there were no significant differences between the girls and the boys except with respect to the number of books that they had at home which might influence their overall understanding of fermentation.**

Since traditional woman do the cooking as well as brewing of traditional beer, it was expected that the girls would perform better than the boys.

- **There seemed to be no clear correlation to relate learners' performances and the frequency of and duration of their visits and stay in the rural areas during their school holidays.**

However, from the Spearman rank correlation which was performed to determine the relationship between the learners' performances as well as their duration and frequency of visits, it was revealed that learners from both groups did much better on items which were categorised as being urban orientated than those which were strictly rural orientated. In support of the above finding, Ogunniyi (2004) has added that:

> ... the mass dislocation of human population in the colonies from their familiar environments for trade, commerce an administration purposes and consequently the loss of indigenous knowledge and skills developed over centuries (p. 290).

Urban settings are different from rural settings in that, in rural areas there is more opportunity for farming, hunting and agricultural practices which are learnt informally. Urbanization as the findings seem to show, has a direct bearing on the children who in turn have to grow having never seen a cow or even know how slaughter a chicken, plant mealies or to develop their own vegetable gardens. Learners growing up in urban settings will normally need to rely only on books for information. Furthermore, even if situations for learning some IK relevant science curricular, probably it would be difficult or impossible to learn certain nuances that only come by being in the community of practice. Despite this, it is difficult considering the congeries of other variables that might be involved. It might be preposterous to jump to the conclusion that the frequency of the visits or lack of it was solely responses for the correlation found.

This finding has implications for C2005 which calls for inclusion and interfacing of IKS with school science (DoE, 2002). Enderstein and Spargo (1998) conducted some longitudinal and cross-cultural studies locally looking into the effects of context, culture and learning on the selection of alternative options in similar situations by South African learners. They came to some conclusion that, the environmental context that a learner finds him/herself predisposes him/her to do better on school science activities that are designed or aligned in favour of a particular socio-cultural environment. The implication for curriculum purpose derived from this study and other similar studies (Ninnes, 2000; Stears et al., 2005) is that, at least relevant and context based learning and teaching materials must be developed so that learners who are from rural or urban backgrounds can have comparable access to science learning experience. As Ninnes (2000) have suggested, this should be done so as to eliminate the bias of not adequately or inappropriately representing IKS in the teaching and learning of school science, including the design of Learning, Teaching and Support Materials (LTSM) (Ninnes, 2000).

5.3 Limitations

5.3.1 End of year school term

The pre-test data was collected in the last term before the end of the year. Several attempts have been made to conduct the study earlier or during mid-year, but because of unavoidable technical issues, the study could not be conducted. One such technical issue experienced was that, the normal protocol in any school is to ask permission to conduct the study from the principal.

The principal would promise to speak to relevant teachers to also find out if they were willing to participate. This process was dragged unnecessarily and hence valuable time was lost. In many cases teachers have refused to participate since they are unionised and cannot be forced. The alternative route was to try and personally speak to teachers and then go to the principal.

In my experience I had found that the best time was only in the beginning of the year. Most teachers during the 2nd term and third term are very stressed trying to keep up with pace setters. Things are generally more quite in 4th term since teachers are doing revision and those teachers who are behind with their work usually borrow other teachers' classroom periods to catch-up. The problem which I faced was that the teacher who was supposed to take the comparison group (C group) in another school started being absent for personal reasons until it was very close to the examinations time and hence the C group had to be aborted. The time proved not to be the best time to conduct this study, since:

- No teacher was willing to do extra work by undergoing training to teach the experimental group.
- Some teachers were more concerned with completing the syllabus.
- Some teachers kept the learners more than their periods required because some were trying to have learners to complete tasks and tests that were required for continuous assessment.
- Some learners felt that the interventions were taking away some of their time to be catching up with the syllabus for the year as a result I lost the teacher for the control group in the control school because she felt that she had lot of work to catch up with. This resulted in me taking up a new group as a control group early in January of 2010 in the experimental school.

It was then decided that the intervention would be done at one school in January 2010 with fresh pre-test data done at the new school, since there would have been no post-test results to compare the former school's pre-test results. The abandoned school's pre-test results were used as additional pilot test data.

5.3.2 Location

The area in which the study was conducted was in the informal settlements where the socio-economic status of the learners was anything but conducive.

- Crime was rampant in the area, in such a way that some learners involved with gangsterism were often absent or late from school because they had to try and 'duck away' from other gangsters who await them on their way to school.

- Because of poverty in the area, most of the learners come to school without money or food for lunch or even had breakfast for that matter. This made some learners not to concentrate or show sufficient interest in class.

Learners from informal settlements are learners who have parents who are at large migrant workers. These learners together and their parents frequently visit rural homes for traditional ceremonies. It was hoped that, using learners from such settings and socio-cultural backgrounds, valuable information would be gleaned from their experiences. In terms of the purpose of the study, it was also decided that although learners from the above background and locations experienced socio-economic difficulties, they were good candidates for interrogation of Science/IKS conceptions of fermentation.

5.3.3 Participant Researcher

Due to time of the year in which the study was conducted:

- There was no teacher willing to accept the new challenge of undergoing training or extra commitment; hence the researcher had to take up the responsibility of being the experimental group teacher.
- Although the researcher had taught in the school before and was acquainted with the learners, a change in the usual teacher might have influenced the way learners respond to the intervention.
- Although a video recording was performed for the research to view issues that might have affected the way the learners respond to the intervention, it might still not capture all relevant activities in the classroom.

Although the issue of a participant researcher was questionable, the reasons for the involvement of the researcher as participant in the study outweighed the advantages of training a participant intervention teacher. The reasons were that:

1. The researcher had designed the whole study and was in a better position of understanding what needed to be done in the intervention classes as well as all related ethical issues.
2. The researcher 'supposedly' understands the intervention strategy better than a would-be participant researcher.

3. The nature of AIM dictates that, in order for it to be effectively implemented, the one administering it should have a fair knowledge and understanding of diverse world view presuppositions. If this is not taken care of, more variables will surely creep in at the analysis stage – because it will be difficult to say whether the intervention strategy worked or not.
4. In order to satisfy the above, an enormous time will have to be dedicated to training.
5. Issues of a participant researcher in the experimental group do not imply, that the participant researcher has content specialist upper hand over the other control group participant.

5.3.4 Intact Classes

As a consequence of the above, two intact classes were taken in the same school. The E and the C group received intervention in January 2010 while the C group pre-test was done without knowledge of that the control group in the other school would be aborted and a new control group be used in the experimental school in January 2010. Due to the fact that learners chat together all the time, these are just some of scenarios that might have occurred during the 2009 and January 2010.

- Learners in the experimental group in 2009 might have shared their experiences and the exciting activities that they performed, hence some contamination.
- In 2010, further sharing might have taken place between the control group which was being taught by another teacher which I frequently observed.
- To minimise the effect of contamination, I scheduled to administer the post-test questionnaire simultaneously for both groups and did the same for the science achievement on a different day.

5.3.5 Duration of Intervention

Due to the time of the end of the year in 2009, the intervention could only be spread over a period of six weeks:

- It would have been desirable to stretch the intervention to at least eight weeks so as to enable the learners more time to absorb and internalise their experiences.

But in view of enormous difficulties school administrators and teachers face in the current examination driven education system, conducting classroom research despite its potential benefits to school was very difficult. This is apart from the hectic nature of the school and other social ills bedevilling the school as indicated above. In such circumstances staying at the school for six weeks was not easy to come by. But I do admit the short duration as a limitation as learning and attitudes take time to get established.

5.3.6 Hegemony of the language of learning and teaching

According to the demographic surveys of the learners, almost all the learners are a second language speakers of English. This could have had a great impact in terms of providing an enabling environment for the learners to voice their opinions. There was sufficient evidence to show that the learners struggled to express themselves fully in English on issues related to their cultural beliefs and values. For instance while some learners were able to express their prior knowledge and beliefs in the mother tongue namely isiXhosa, they could not do so in English. Unfortunately, due to the hegemony of English and despite the permission given to the teachers to express their views or conceptual understanding in their own language, they nevertheless used English. But in using the latter they tended to use inappropriate English words and thereby made unclear statements. The same handicap affected their ability to argue their views in a comprehensive manner. Based on the experience garnered in this study it became obvious that future research in this or similar school setting would warrant the use of bilingual or code switching instruction. A future study in which emphasis is placed on language of instruction is worthy of consideration.

5.4 Implication of the findings

The findings of this study have implications for curriculum development and instructional practices. The findings of this study have again re-affirmed the importance of classroom research as a critical aspect of curriculum implementation. It is one thing to design a new curriculum but another matter to see it work in the classroom setting. An important lesson that can be drawn from this experience is that there is a wide gap between curricular idealization and implementation. Secondly, the current school and classroom context warrants a closer consideration by curricular planners. Thirdly, a new curriculum development without adequate teacher preparation is not likely to succeed at all (Jansen & Christie, 1999). The following issues are worth of scholarly attention:

- Teachers, curriculum advisers, curriculum planners and Education Management District Coordination (EMDC) official will need retraining.
- Institutions of higher learning will need to re-align their teacher education programs to develop teachers that are able to apply argumentation practices in their day to day teaching practices.
- New teaching and learning materials that interface science and IKS will need to be developed.
- The basis and foundation of science is argumentation, since it is argued that science as discipline is a human construct which in turn means that, in order for it to stand it needs argumentation as its legs (Erduran, 2006). The issue is, Are teachers well equipped to teach argumentation-based lessons?
- Learners who can argue will not only develop the scientific skills, knowledge, values and attitudes, but will also understand how science works and is developed (Ogunniyi, 2008). The question begging for an answer is, do learners in the previously disadvantaged schools possess sufficient English to express themselves in that language?
- The rote learning teacher-centred approach do not coincide with the development of process skills and high-order skills demanded by the new curriculum (DoE, 2002). Although an argumentation based classroom provides an enabling context for freedom of expression however, are teachers and learners equipped to engage in this form of teaching and learning process?

It seems obvious from the above that a dialogical argumentation-based instruction pre-supposes adequate training on the part of teachers who in turn will equip their learners with necessary skills on the protocols of argumentation as thinking process.

The disadvantages of argumentation are dependent on a number of factors. These factors that can lead to argumentation not working efficiently as depicted below:

- If teachers are not well trained, both in the use of argumentation as well as their content knowledge, then any attempts to apply an argumentation instructional methodology can prove to be a waste of time. (Jansen & Christie, 1999).
- If teachers use a method of teaching in which they lack necessary skills as was the case in the C group, then learners' awareness about

and understanding of the NOS and NOIKS will diminish instead of being enhanced. (Ogunniyi & Ogawa, 2008)

- If the language in which the learners are most comfortable with is not taken into consideration, then the efficiency of this teaching strategy might be undermined.
- The method of argumentation will need a lot of preparation for each task. If preparation is poor, then the efficiency of the method will again be undermined. (Stone, 2009)

In conclusion, argumentation can prove to be a very crucial teaching and learning tool such that learners are able to develop and apply scientific knowledge in a responsible manner. When situations requiring informed decision-making on socio-scientific issues arise, they will be in a better position to take necessary steps than depend on the gut feeling or trial an error approaches. (Ogunniyi, 2007a; Erduran, 2006).

5.5 Conclusions

Argumentation, though on the surface sounds like a very simple and easy task to perform in the classroom, it has proved to be an instructional method that requires thorough pre-thinking and careful preparation. The finding from classroom observation and focus group interviews strongly suggested that, teachers without training or awareness about the nature of science (NOS) and the nature of IKS (NOIKS) will hardly be in a position to transfer a healthy perspective about school science on the one hand and IKS on the other. For instance, without a dialogical argumentation approach it would have probably been impossible to obtain or to describe the learners' conceptions of fermentation 'accurately' since, 'ideas that are unlinked to the content in an adult scientific logical sense may be linked for the student' (Marin et al., 2001: 685). To make an example, the when observing the C group teacher, it was obvious that, the teacher in some instances did not view learners' conceptions about what he was teaching as being linked to the content. In other words, the search for prior knowledge should not only be about whether the learner ideas were correct or not correct, but the job of the educator should be to ask him/herself why learners think or exhibit certain ideas which do not linking to the content (as viewed from the adult world) . One way of facilitating such inquiry would not necessarily to be conducting interviews, but to use dialogical/discursive activities which will enable learners to come forward with the

reasons in support of their conceptions, thus be co-producers of their own knowledge (Aleixandre, 2002). Although the intervention was for a very short time (6 weeks), argumentation as an instruction method seemed to be working even for shorter periods. The above finding is further vindicated by the fact that, the learners in the experimental group though not used to this method of teaching still showed enthusiasm for it. The other important conclusion to be made is that, argumentation did not necessarily lead to decrease in the amount of content knowledge that needed to be addressed for a particular topic. In fact, it appeared to enhance the learners' understanding of the topic.

Although there were intervening variables as explicated in the limitations' section above, the study was not without some positive indications. In terms of the purpose of the study and the research questions, important observations and finding were noted, though much still has to be done in future studies in the area. For example it would be instructive to know how much factors as: how bilingual instruction and code-switching affect learners' performance and attitudes towards Science and IKS. Whether or not an indigenised science curriculum enhanced learners' interest in science; the impact of teacher training in higher education or argumentation/discursive instruction on teachers' ability to implement a science or Science-IKS curriculum, how learners' exposed to the DAIM compared with learners not so exposed perform on other topics etc.

5.6 Recommendations

In the light of the implications and conclusions of this study there were many issues relating to the inclusion of IKS into the mainstream school science syllabus. Some of the issues are as follows:

- The diverse nature of epistemic authorities underpinning school science and IKS. In the light of this view, the RNCS/NCS policy documents will have to be revisited to clearly and unequivocally spell out the role of IKS in science teaching. That is, for purposes of teaching , assessments and examination, the issue of what aspects of IKS could be examinable should be clarified (See, Finley, 2009; Mosimege and Onwu, 2004 and Onwu, 2009).
- Many teachers complain that, there is very little IKS component in the examination question. This finding has generally led teachers to view IKS as a 'starter' for 'western science'. In the light of this, it is

recommended that , instead of trying to strike a balance between how much of IKS or what kind of IKS is to be included in the school science curriculum, an IKS-contextualised curriculum be adopted. This can be compared to the Japanised school science (Rika) which is intended to enculturate learners into school science (Ogunniyi & Ogawa, 2008).

The findings of this study have, indicated that the introduction of IKS as only an ice breaker could easily give learners the impression that their home-based knowledge is sub-servient to school science. This might alienate learners from school science. However, to develop the emancipator knowledge (i.e. knowledge owned by learners) demands that their indigenous knowledge is respected – even when it is distinctively different from that of science as Ogawa (1993) has argued:

> … The Japanese never lost their cultural identity when introducing western science and technology, because they introduced only the practical products of western science and technology, never its epistemology or world view (Ogunniyi et al., 1995).

The above argument by Ogawa as cited in Ogunniyi et al. (1995) seems to suggest that; argumentation can help in making learners proud about their culture. As a final conclusion, I will make a linguistic analogy of the hegemony of science. Alexander (2002) in his article 'English unassailable, but unattainable' refers to the misleading hegemony of English. While the 'West' demands good command of English from those who are non-western, it forgets that English is learned in a language which is not English itself. This is a lesson that can be learned for school science enculturation in terms of interfacing IKS into school science curriculum. It seemed from the finding of this study that argumentation used in a structured form and systematic manner could provide that vital link for relating what learners study at school with what they do and learn in their socio-cultural environment. In view of the small scope of the study it is hoped that the experience gained and presented in this report might prove informative and useful to researchers working in the area.

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