COVER SHEET TO PRESENT AT THE SAARMSTE 2012CONFERENCE

I am/we are submitting the following contribution to the Programme Committee for consideration for presenting at the **SAARMSTE 2012** Conference to be held in Malawi, Crossroads Hotel from 16th to 19th January 2012.

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Evaluating Skills, Knowledge and Values of learners exposed to a dialogical argumentation instruction and the traditional lecture method on fermentation.

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This case study which is part of a larger project, the Science and Indigenous Knowledge Systems Project (SIKSP) at the University of the Western Cape reports on findings of two cohorts of grade 10 science learners whose conceptions of fermentation as well as their Skills, Knowledge, Attitudes and values (SKAV's) on fermentation processes was assessed. One group was taught using Dialogical Argumentation Instruction (DAI) while the other group was taught using the Traditional Lecture Method (TLM) on the same topic, but taught by another experienced teacher.

After the interventions which lasted a period of six weeks, both groups were again evaluated using the same conceptions questionnaire as well as a science achievement test to evaluate their SKAV's on activities of various cognitive abilities.

This study employed a pre and post-test quasi-experimental design augmented with a qualitative design. The findings showed that learners exposed to dialogical approach developed higher knowledge, process skills, reasoning skills and values as compared to their counterparts who were taught using the TLM approach.

INTRODUCTION

There has been a loud outcry within the South African education and industrial circles in following the introduction of the New Curriculum in 1997. The curriculum was introduced in response to South Africa's socio-political history which is believed to be having a contributing factor to the country lagging behind other countries in terms of international learner attainment standards. Industries as well as institutions of higher learning have complained that, while there is evidence of 'factual knowledge', among graduates and learners, 'procedural knowledge which is the use of knowledge in context (Winterton, cited in Badat, 2008) is not evident. More recently in 2006 the then Deputy President Mlambo-Ngcuka commenting on the notion of 'skills revolution' argued that:

> …the curriculum developers are not paying enough attention to issues of relevance and ensuring that we all pay attention to the skills and competencies learners require when they come out of higher education (Griesel & Parker, 2009).

While the new curriculum places emphasis on group work activities that are expected to achieve certain Learning Outcomes (DoE, 2002) or Specific Aims (CAPS, January 2011) draft document, it does not spell out what methodology teachers should follow to facilitate effective implementation. In this regard, the November 2009 Ministerial Final report also admitted that the problem was implementation and tried to identify some issues and the nature of the challenges involved. For example, only issues such as advocacy, infrastructure, learning and teaching materials were explicit (DoE, 2009).

It is within the above context that this study is imbedded. As Stears, Malcolm & Kowlas (2003) rightfully put it:

> While an individual's knowledge is personally constructed, the constructed knowledge is socially mediated as a result of cultural experiences, personal history, interaction 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 support of the above and more explicitly, Erduran (2006) argues that since science is a human construct and as such is nourished and growing on argumentation, and as (Newton, 1999; Ogunniyi, 2007 a & b, 2008) have argued, learners should be afforded the opportunity to voice out or externalize their views so that a cognitive consensus could be reached. Central to learners' problem-solving strategies is their understanding of and the awareness of the NOS and NOIKS which can only come through teaching and learning styles that develop argumentation skills (Lin & Chiu, 2004; Ogunniyi 2004, 2007a & b). In the words of Hall and Simpson (2009):

> 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).

At the heart of scientific argumentation is critical thinking which Fogler (1999) defines as a process of reflecting on, assessing and the ability to justify one's own assumptions as well as others' ideas, work and actions.

The concept of fermentation has been used in this paper as an exemplification of a topic showing elements of both school science and learners' out of school experiences. Most home-based and industrial-based foods and beverages use the process of fermentation. Fermentation is also a very important process involved in most medical and biotechnological products and hence its choice as a topical concept worthy of closer consideration. Fermentation is a concept whose biological processes involve microbes. The above fact has implications that suggest that, in order to create a teaching and learning environment for learners from indigenous communities towards understanding the microscopic and counter-intuitive biological changes that occur, they may require a measure of border crossing between what they currently know and what they need to learn about with respect to the science of fermentation in the science classroom.

THEORETICAL UNDERPINNINGS

Several studies conducted to investigate the effectiveness or otherwise of an argumentation instructional model as a strategy in the teaching and learning of science show that it does enhance the educators and learners' awareness and understanding of the NOS (Erduran, et al, 2004, Simon et al, 2006). For instance, 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). Put another way, argumentation can enhance the development of learners' skills, knowledge, values and attitudes. It is within this context that this paper argues for a structured process of group work discussions in order to promote clarity and direction in the process of dialogical argumentation upon which science thrives.

Since this study concerns itself mainly with evaluating the deductive/inductive aspects of school science, Toulmin's (1958) Argumentation Patten (TAP) has been chosen as framework that is most suitable for the summative evaluation of learners' Skills, Knowledge, Attitudes and Values. According to Aleixandre (2002), TAP is underpinned by 'substantive arguments' where knowledge of subject content is a requisite (p. 1172). As explicated by Ogunniyi (2008), Toulmin's Argumentation Pattern (TAP) consists of a claim, evidence (data), warrant, backing, rebuttal and a qualifier. Accordingly, a 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.

PURPOSE OF STUDY

The purpose of this study was to evaluate the skills, knowledge values and attitudes of grade 10 learners' exposed to a Dialogical Argumentation Instruction (DAI) as well as those on the Traditional Lecture Method (TLM) teaching approach.

RESEARCH QUESTIONS

1. What are learners' pre-post generalized knowledge and conception on fermentation?
2. How does the DAI and TLM affect the learners' ability to develop critical thinking skills, knowledge coupled with attitudes and values?

METHODOLOGY

Two groups of grade 10 intact classes from a township school were selected. For purposes of analysis, each group contained 21 learners (11 boys and 10 girls per group). The experimental group (E group) was taught using a DAI approach. At the beginning of each lesson each learner was given an individual activity worksheet and TAP writing frames. Each group had a group working sheet. The focus of the lesson and the 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).The educator facilitated the group activities by posing leading or probing questions. When the group tasks were completed, a whole class argumentation was started where the members of each group argued among themselves before reaching consensus and some sort of understanding. The teacher recorded the whole class claims, counter claims and rebuttals. Finally, the teacher would do a consolidation of ideas and clarify issues with respect to the targeted content learning outcomes. The comparison group (C group) was provided with learning materials on Science and IKS conceptions of fermentation, but taught by another comparable teacher using the (TLM) approach. The learners' prior knowledge was assessed before the interventions and again assessed after a period of six weeks of which the intervention lasted.

This study employed both quantitative and qualitative research methods where all data was derived from the learners' performance scores and written responses in the pre and post-test Conceptions of Fermentation Questionnaire (COFQ and the Science Achievement Test (SAT) respectively. The two COFQ and 20 SAT items which were used for evaluating the learners' skills, knowledge and values were coded as follows prior to them even being admistered: Recall (R), Conceptual Understanding (CU), Process Understanding (PU), Knowledge Application (KA) and Socio-scientific Understanding (SSU). The quantitative aspect of the study used a quasi-experimental pre-test post-test control group design. All statistics were obtained by using SPSS statistics software. All instruments were subjected to face validity, content as well as construct valid by peers, educators and experts held on every Fridays and Saturdays at the Science and Indigenous Knowledge Systems (SIKS) project workshops. The Cronbach alpha reliability values obtained for all instruments in the pilot study as well as in the main study were greater than 0.7 (Ogunniyi, 1992, Pallant, 2001).

DATA ANALYSIS
Overall statistics for the 8 COFQ, 2 COFQ items and 20 SAT instruments was reported upon including some excerpt items from COFQ were selected and compared to SAT items to highlight trends in skills, knowledge, attitudes and values (SKAVs) attained by the study subjects.
2 out of 8 COFQ items were reported and analyzed in terms of 5-point scale.

RESULTS AND DISCUSSIONS

TABLE 1. Learners' pre-test and post-test overall conceptions of fermentations.

ITEMS	GP	PRE	POST	t-ratio	t-critical @ df = 20
All 8 ITEMS	E	20.12	27.12	-6.598	2.086
	C	22.88	15.88	-1.866	2.086
t-ratio		-7.58	7.222		
T-critical = 2.025 @ df = 40					
ITEM 3	**GP**	**PRE**	**POST**	**t-ratio**	**t-critical @ df = 20**
Knowledge of malting process	E	18.76	24.64	-4.787	2.086
	C	24.24	18.36	-1.033	2.086
t-ratio		-1.36	2.019		
T-critical = 2.025 @ df = 40					
ITEM 4	**GP**	**PRE**	**POST**	**t-ratio**	**t-critical @ df = 20**
Knowledge of traditional Alternative of yeast	E	18.93	25.31	-3.910	2.086
	C	24.07	17.69	-0.052	2.086
t-ratios		-1.69	5.862		
T-critical =2.025 @ df = 40					

Alpha value is 0.05; * significant difference.

Pre Intervention discussion of COFQ

Table 1 above gives the overall statistics of the COFQ as well as data for selected items. The discussions focus on the latter due to space limitation. An examination of the results 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 which are half the total of 40 points for the 8 items. A no-significance result of **t = -7.58 at p=0.453** was obtained, also confirming that the two groups were indeed comparable. Based on the pre-test quantitative data, the two groups were similar in terms of their conceptions of fermentation. In terms of the skills, knowledge, attitudes and values attributes, that is; SKAVS, both groups performed comparably in the pre-test of items 3 and 4 where both items required Conceptual Understanding (CU) and Process Understanding (PU) in traditional beer making. In conclusion, the results suggest that both groups held to some degree valid scientific/IKS notions about fermentation.

Post Intervention discussions of COFQ

An examination of Table 1 shows that the E group's overall mean rank score (27.12) in the COFQ was significantly higher compared with 15.88 of the C group. The independent group t-test value gave a significance at t = 7.222. 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) compared with that of the C group (t = -1.866). In terms of overall SKAVS required for performance, it can be argued that the DAIM enhanced the E group SKAVS significantly from pre-test to post-test stages. This observation is corroborated by the significant results (t = -4.78) obtained by the E group in item 3 and (t = -3.910) for item 4 as compared to the C group's (t = -1.033) for item 3 and (t = -0.052) in item 4. Both items 3 and 4 required CU and PU knowledge attributes. The statistical tests tabulated in table 1 suggest that the DAIM which the E group was exposed to might have been responsible for the E group outperforming the C group. The following excerpts show some of the learners' TAP argumentation shifts from pre to post-test.

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].**

The 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 inoculant beer (called ivanya – borrowed from vino or vine) 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. This indicates that learner lacked conceptual understanding of what caused fermentation and probably had no process or practical experience in traditional bread making. The post-test response reveals that this learner has acquired some conceptual knowledge of the fermentation process used in traditional beer making and linked that knowledge to the concept of yeast and as she might possibly picked such knowledge during the dialogical lessons where learners had opportunity to discuss and to share their experiences with each other. It is through this experience that she might have picked up that there was a similarity between yeast and traditional beer which has live yeast cultures in it. In this regard, the learner decided to claim 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 and process understanding among the E group learners. Examination of the responses among learners in the C group revealed the following:

Learner C 24 (pre-test): "They use baking powder'

Learner C 24 (post-test): "It is the sun"

Learner C 24 pre-test response shows that she did have some ideas about baking of bread at home, but she 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. Contrary to learner E 15, this learner was able identify baking powder as an alternative to yeast although not home-made, but changed her view in the post-test stage while E 15 could have assumed that a home-made ingredient could be the conditions of a warm place. For learner C 24 who was exposed to the traditional teaching approach there was no concerted effort to discuss the relationship of concepts between industrial and home-made fermented products. When faced with open-ended question not requiring school science knowledge most of the C group learners on this item opted for 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. This decrease can be seen with learner C 24 who had some good idea of a baking ingredient in the pre-test, but soon ran out of ideas as it probably became impossible for her to link school science concepts with those of out of school experience. Cajas (1999) have argued that, in order for learners to be in a position to relate school science to their everyday lives, they would require a better understanding of the relation between the two forms of knowledge.

The Science Achievement Test (SAT)

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. Both the Experimental group teacher as well as the experimental group teacher had access the SAT for minimizing any biases that would have been as a result of one teacher teaching to the test. The purpose of the SAT, sought to evaluate the overall effectiveness or ineffectiveness of the interventions made to the two groups of learners. In particular, special attention was put on evaluating learners' skills, knowledge, values and attitudes attained as a result of the interventions administered. To facilitate this and for purposes of analysis and discussion, the SAT items were further categorized in terms of Toulmin's argumentation framework at individual levels of argumentation where learners' claims, reasons/evidence and warrants presented were evaluated. The scale was designed adapting Toulmin's Argumentation Pattern (TAP) as follows:

1 = no claim/argument, 2 = Claim and no reason, 3 = Claim with a reason, 4 = Claim with a valid 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.

Table 2.1 and 2.2, one below one another give the statistical results of the E and C group respectively. As a reminder the SKAV's were coded as is described in the methodology.

TABLE 2. ***Learners' SKAVs performances in the Science Achievement Test (SAT)***
N = 21, T-critical = 2.025 @ df = 40, * = 2-tailed significant difference @ α = 0.05

ITEMS	GP	Mean	t-ratio	SKAVs
ALL 20 items combined	**E**	**27.95**	**4.27**	**N/A**
	C	**15.05**		
1. Defining fermentation	**E**	**23.71**	**1.18**	**R**
	C	**19.29**		
2. Identifying fermentation products	**E**	**28.69**	**5.82**	**R, CU, KA**
	C	**14.31**		
3. Relating fermented product with	**E**	**28.69**	**4.75**	**R, CU, KA**
with specific micro organisms.	**C**	**14.31**		
4. Naming sugars and their sources	**E**	**22.14**	**0.12**	**R**
	C	**20.86**		
5. Temperature effects on fermentation	**E**	**27.33**	**3.63**	**R, CU,PU,KA**
	C	**15.67**		
6. Defining an enzyme	**E**	**23.50**	**1.58**	**R**
	C	**19.50**		
7. Function of enzymes on sugars	**E**	**20.57**	**-1.29**	**R**
	C	**22.43**		
8. Role of microbes in nature	**E**	**24.36**	**0.08**	**All SKAVs**
	C	**18.64**		
9. Role of fermentation in society and the environment.	**E**	**25.33**	**2.36**	**R,CU,PU, SSU**
	C	**17.69**		

10. Comparing industrial and traditional beer	**E**	**28.90**	**5.066**	**R, PU, SSU**
	C	**14.10**		
11. Why some fermented brews have little or no alcohol	**E**	**26.71**	**4.074**	**R, CU, PU**
	C	**16.29**		
12. Alcohol advantages and disadvantages in society.	**E**	**27.26**	**3.570**	**R,CU,KA,SU**
	C	**15.74**		
13. Defining aerobic and anaerobic fermentation.	**E**	**23.14**	**1.360**	**R**
	C	**19.86**		
14. Naming home-made yeast alternative	**E**	**23.90**	**1.334**	**R**
	C	**19.10**		
15. Starch fermentation process	**E**	**21.95**	**0.172**	**R, PU**
	C	**21.05**		
16. Health effects of malting process.	**E**	**23.02**	**0.485**	**R,CU,PU,SSU**
	C	**19.98**		
17. Naming the sour substance in fermented products.	**E**	**23.52**	**0.566**	**R**
	C	**19.48**		
18. Naming the bitter substance in fermented products.	**E**	**24.48**	**0.181**	**R**
	C	**18.52**		
19. Naming microbes responsible for sour fermented products	**E**	**22.38**	**0.415**	**R**
	C	**20.62**		
20. Naming microbes responsible for bitter fermented products.	**E**	**22.36**	**0.410**	**R**
	C	**20.64**		

Observations in Table 2 above 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 t-ratio at α = 0.05 where the t-ratio is larger than the T-critical value of 2.025. This observation shows that, the E group's mean rank score was significantly higher than that of the C group. For all other items, only the t-ratios will be cited to avoid repetition of process. In 13 items (1,4,6,7,8,13,14,15,16,17,18,19,20) of the 20 items presented, the two groups performed comparably. In the remaining 7 items the E group performed significantly higher than the control group. Using the SKAVS codes it can be seen that 10 of the 13 items where both groups performed comparably were only R=Recall memory questions and only 8, 15 and 16 required other knowledge attributes. Further exploration of items 8, 15 and 16 reveal that both items require more of local context knowledge which suggests that their level of difficulty was not as high as one would have generally assumed. The observation of items 8, 15 and 16 is corroborated by a similar item, item 3 of COFQ (Table 1) in both pre and post-test scores where there was no significant difference between the two group mean scores. This suggests that the two groups performed comparable on all items which were of low order cognitive ability. Looking closer at the 7 items where there is significant difference in the groups it is observed that they all required skills ranging from R, CU, PU, KA and SSU about fermentation processes, hence high order reasoning skills were required. This observation seems to suggests that learners exposed to a dialogical instructional method will not only be able to grasp concepts, process understanding and dealing with socio-scientific issues on alcohol fermentation, but were also in a position to apply that knowledge when and where it was required during decision making processes. The performance of the E group in the 7 items was such that the E group performance was so high to such an extent that the E group received an overall significant result for all 20 items combined.

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.
- 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 while the other 3 items (8, 15 and 16) required local context knowledge which also suggests that all learners might have found them to be easier and hence the reason why both groups might have performed comparable on them.

Based on the findings of the COF questionnaire and the SAT questionnaire, it seemed that the DAI (compared to TLM used for in the C group) significantly improved the E group's SKAVS regarding the concept of fermentation. The findings obtained also showed that, the DAI seemed not only to have improve the E group's performance, but also enhanced their understanding of socio-scientific issues as well as demonstrated high-order reasoning skills where such knowledge and skills are required for unfamiliar contexts. This view is based on the fact that the DAI is an enquiry-based method that is designed to incite learners to explore and to find answers, hence an extenuating factor as a built-in component to the DAI method.
In the light of the above findings, it was concluded that, the DAI was effective in enhancing the SKAVs of grade 10 learners on the topic of fermentation.

FINDINGS AND FURTHER DISCUSSIONS

The major findings in this study were as follows:

- **Learners in both study groups held relatively good conceptions, of fermentation processes in their pre-test score, however the E group performed significantly better as compared to the C group in post-test.**

According to Le Grange (2004) learners do possess knowledge that could potentially be 'lost' if not properly harnessed. In this regard, Jegede (1996) has also warned that, it care is not taken regarding learners' pre-conceptions which he calls 'mysteries', they are capable of causing blockages to any scientific knowledge the child might acquire as a result of schooling" (p. 18).This statement is important more so that the New South African Curriculum (DoE, 2002) as well as the proposed Curriculum and Assessment Policy Statement (CAPS) has also reinforced the integration of learners' local knowledge with that of school science The general trend in science teaching and science education has been to attempt to change learners' indigenous conceptions of various natural phenomena to the scientific worldview (e.g. Posner et al, 1982) but these have not resulted in much success as earlier been found by Gunstone and White

(2000). The Revised National Curriculum Statement (RNCS) Grades 8 to 9 and the NCS Grades 10 – 12 (DoE, 2002) in terms of its Outcome-based education policy states that "it strives to enable all learners to achieve to their maximum ability" (p. 1). This document further argues that, its envisaged "outcomes encourage a learner-centered and activity-based approach to education" (ibid). Both of these documents encourage group work activities and discursive classrooms. The above statement is consonant with the dialogical argumentation approach which is learner-centred and activity-based which the E group was exposed to. The TLM which the C group was exposed to is characteristic of a 'chalk and talk' approach where learners do not find the opportunity of externalizing their views and misgivings (Fleer, 1999; Newton et al, 1999; Ogunniyi, 2007a & b, 2008).
As a corroboration of the consequences of a 'chalk and talk" approach as has been observed in the C group, their performances for the COFQ after the interventions was significantly lowered suggesting perhaps as Jegede (1996) have warned that dissonances may occur if the teaching approach which is not consonant with the spirit of a science and IKS curriculum. In support of Posner et al, and Ogunniyi, Ogunsola-Bandele (2009) has also stated that science and IKS should be allowed to co-exist and that points of intersection between the two knowledge corpuses should be established so as to enrich the learners' reasoning processes, conceptual understanding and decision-making skills.

- **Learners exposed to a DAI showed to have developed varied skills beyond just memory recall questions, but were able to display such SKAVs. In terms of the COFQ and the SAT instruments, the E group performed significantly better on all items that required high order reasoning and decision skills which are beyond just memory recall questions than the C group.**

According to Tobin & Garnett (1988), 'high level cognitive learning' involving the development of learners' skills to use of knowledge in unfamiliar context 'has been an elusive goal for science programs for many years' (p. 197). A similar view have also been expressed by Cajas (1999) where he argues that although "connecting school science with students' everyday lives is an educational goal which looks simple, plausible and desirable" (p. 766), however it is "…complex, difficult and rarely studied" (ibid). Recently Badat (2008: p. 4) in a paper presented at the Eastern Cape Skills Indaba have made a call for:

> …agreeing that for economic and social development we require competent people; and that, moreover, such competent people need to posses different kinds of competencies–'cognitive' competencies (Knowledge), 'functional' competence (skills) and "personal and social-attitudinal competence" (as cited in Winterton et al).

While the New South African Curriculum is in agreement with the above call and as such is still advocating for the acquisition of such skills, it nevertheless has been able to find a common ground for its policy and practice. Winterton (as cited in Badat) argues that knowledge is "the result of an interaction between intelligence (capacity to learn) and situation (opportunity to learn)" (Badat, 2008: p. 4). In terms of the E group's performance and the C group, it can be argued that both groups have the capacity to learn (as has been observed in their COFQ pre-test results), but due to the different teaching methods (having their own merits and demerits) they were exposed to, the E group significantly outperformed the C group with respect to the acquisition of SKAVS. For the C group, it can be argued that there was little or no interaction between their ‘capacity to learn’ and the ‘opportunity to learn’ as in a traditional lecture method approach (ibid). As Tobin & Garnett (1988) have put it, in “traditional teaching methods …student outcomes are associated with memorization of science facts and algorithms to solve problems without necessarily understanding how the algorithm works” (p. 197). In agreement with Badat (2008) and Tobin & Garnett (1988) on the consequences of a traditional teaching methods that, perhaps contrary to what scholars such Fleer, (1999), Newton et al (1999), and Ogunniyi (2007 a & b, 2008) have suggested, the C group learners were not afforded the opportunity to voice out or externalise their views so that a cognitive consensus could be reached whereby they could have developed the necessary SKAVs as have been observed among the E group learners. The positive aspect of the conceptual change theory as has been noted by scholars such Posner et al and others (for example, Hewson, 1988; Hewson & Hewson, 1988, 2003) has been in the incorporation of teaching and learning approaches that value the learners’ prior learning in the teaching-learning process. In the case of the E group, the learners’ prior knowledge was utilized in the development of the three various competencies as highlighted by Badat (2008) employing the mechanisms of the DAI which they were exposed to.

CONCLUSIONS

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). The notion is consistent with the valuing of learners’ prior knowledge in mitigating cognitive and conceptual barriers. Learners develop holistic knowledge when they can internalize and own such knowledge, thereby being enabled to make informed decisions for different contexts. From the findings it seems that learners (e.g. C group) exposed to teacher-centered traditional teaching and learning methods that do not allow argumentation practices in science and IKS curriculum classroom will incur dissonances that would result in impossible border crossing or cultural violence as alluded to by Aikenhead (1996).

Although, DAI seem to require a lot of time to implement, it seemed to be effective in facilitating a learner-centered environment and the enhancement of teacher and learners’ awareness of and understanding of the Nature of Science (NOS) and the nature of IKS (NOIKS) (Ogunniyi, 2007a & b; Ogunniyi, 2009; Ogunniyi & Hewson, 2008; Ogunniyi & Ogawa, 2008). Furthermore, the DAIM seemed to be shortening the teaching time on a topic when taken over a longer period.

REFERENCES

Aikenhead, G. S. (1996). Science Education: border crossing into the subculture of science. *Studies in Science Education*, 27, 1 – 52.

Aleixandre, J. M. (2002). Knowledge producers or knowledge consumers? Argumentation and decision making about environmental management. *International Journal of Science Education.* 24(11), 1171 – 1190.

Badat, S. (2008). Beyond the Obsession with skills and Towards a Discourse of Knowledge, Skills and Attitudes. Paper presented at the Eastern Cape Skills Indaba, February 2008. East London: The Eastern Cape Socio-economic Consultative Council.

Cajas, F. (1999). Public understanding of science: using technology to enhance school science in everyday life. *International Journal of Science Education, 21(7), 765 – 773.*

Department of Education, Republic of South Africa. (2002). Revised National Curriculum Statement for grades R-9 (Schools) - Natural Sciences. Government Gazette, Vol.443 No. 23406. Pretoria: Department of Education, Republic of South Africa.

Department of Education, Republic of South Africa. (2009). Report of the Task Team for the Review of the Implementation of the National Curriculum Statement: Final Report, October 2009, Presented to the Minister of Education, Ms Angela Motshega; Pretoria, South Africa.

Department of Basic Education, Republic of South Africa. (2011). Curriculum and Assessment Policy Statement (CAPS) grades R-12 (Schools). Pretoria: Department of Basic Education, Republic of South Africa.

Erduran, S., Simon, S., & Osborne. (2004). TAPing into argumentation: Development in the use of Toulmin's argumentation pattern in studying science discourse. Science Education, 88(6), 915 – 953

Fleer, M. (1999). Children's alternative views: alternative to what? *International Journal of Science Education,* 21(2), 119 – 135.

Fogler, H. S. (1999). *Elements of Chemical Reaction Engineering,* Third Edition. Upper Saddle River, New Jersey: Prentice-Hall Inc.

Griesel, H. & Parker, B. (2009). *Graduate Attributes: A baseline study on South African graduates from the perspective of employers.* Higher Education South African & the South African Qualifications Authority. Context and Overview, p. 2.

Gunstone, R. and White, R. (2000). *Goals, methods and achievements of research in science education.* In R. Millar, J. Leach and J. Osborne (eds) Improving Science education: The contribution of research. pp. 293-307. Buckingham: Open University Press.

Hall, C. B. & Sampson, V. (2009). Helping Students Learn Important Concepts and Practices: Inquiry, Argumentation and the phases of the moon. Science Scope, April/May 2009.

Jegede, O.J. (1996). Fostering Students' Understanding of Science Concepts. *A special Keynote paper for the 37th Annual Conference of the Science Teachers' Association of Nigeria, Uyo, Akwam Ibom State, 12 – 17 August 1996.*

Hewson, M.G. (1988). The ecological context of knowledge: Implications for teaching science in the third world. *Journal of Curriculum Studies,* 20(4), 317-327.

Hewson, P. W & Hewson, M. G. (1988). An appropriate conception of teaching science. A view from studies of science learning. Science Education, 72(5), 597- 614.

Hewson, M.G. & Hewson P.W. (2003). The effect of students' prior knowledge and conceptual change strategies on science learning. *Journal of Research in Science Teaching*, 40, S87-S98.

Le Grange, L. (2004). 'Multicultural'Science in South Africa's National Curriculum Statement, *Africa Education Review*, 1(2), 204 – 219.

Lin, H. S., Chiu, H. L. & Chou, C.Y. (2004). Students' understanding of the nature of science and their problem-solving strategies. International *Journal of Science Education*, 26(1), 101 – 112.

Marin, N. M., Solano, I. & Jimenez, E. G. (2001). Characteristics of the methodology used to describe students' conceptions. *International Journal of Science Education*, 23(7), 663 – 690.

Newton, P., Driver, R., and Osborne, J. (1999). The place of argumentation in the pedagogy of School Science. *International Journal of Science Education*, 21(5), 553 – 576.

Tobin, K. & Garnett, P. (1988). Exemplary Practice in Science Classrooms. *Science Education. 72(2), 197 – 208.*

Toulmin, S. (1958). *The uses of argument*. Cambridge, UK: Cambridge University Press.

Ogunniyi, M. B. (1992). *Understanding social science research*. Ibadan: University Press.

Ogunniyi, M. B. and Hewson, M. G. (2008). Effect of an Argumentation-Based Course on Teachers' Disposition towards a Science-Indigenous Knowledge Curriculum. *International Journal of Environmental & Science Education*, 3(4), 159 – 177.

Ogunniyi, M. B. and Ogawa, M (2008). The prospects and challenges of training South African and Japanese educators to enact an indigenized science curriculum. *South African Journal of Higher Education*, 22(1), 175 – 190.

Ogunniyi, M. B. (2007a). Teachers' stances and practical arguments regarding a science-indigenous knowledge curriculum, paper 1. *International Journal of Science Education,* 29(8), 963-985.

Ogunniyi, M. B. (2007b). Teachers' stances and practical arguments regarding a science-indigenous knowledge curriculum, paper 2. *International Journal of Science Education,* 29(10), 1189-1207.

Ogunsola-Bandele, M. F. (2009). Blending science with indigenous knowledge to enhance learners' understanding of natural phenomena. Second Nation Workshop on Science and Indigenous knowledge Systems, 29th – 31st October 2009. University of the Western Cape.

Pallant, J. (2001). *A step by step guide to data analysis using SPSS.* Berkshire, Open University Press.

Posner, G. J., Stirke, K. A., Hewson, P. W., and Gertzog, W. A. (1982). Accommodation of a scientific conception: Towards a theory of conceptual change. Science Education, Vol. 66, No. 2, pp. 211-227.

Stears, M., Malcolm. C. and Kowlas, L. (2003). Making use of everyday knowledge in the science classroom. *African Journal of Research in Science, Mathematics and Technology Education*, Volume 7, 109 – 118.

Simon, S., Erduran, S. and Osborne, J. (2006). Learning to Teach Argumentation: Research and development in the science classroom. *International Journal of Science Education*, 28(2-3), 235 – 260.

Toulmin, S. (1958).*The uses of argument*. Cambridge, UK: Cambridge University Press.