TITLE OF THESIS

Effects of an Argumentation-Based Instruction on grade 10 learners' understanding of the causes of pollution at a river site.

By

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DECLARATION

I declare that **"Effects of an Argumentation-Based Instruction on grade 10 learners' understanding of the causes of pollution at a river site "** is my own work; that it has not been submitted before for any degree or examination in any other university, and that all sources I have used or quoted have been indicated and acknowledge by complete references.

RUBEN CLIVE MAGERMAN

SIGNED: ………………………………….. **DATE: MAY 2011**

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ABSTRACT

This study was based on 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 (Toulmin Argument Pattern) to the extent that learners would value the significance of both worldviews.

This study sought to find the effects of an Argumentation-Based Instruction on grade 10 learners' understanding of the causes of pollution at a river site. Since the integration of Science and IKS are envisaged by Curriculum 2005 (C2005), two theoretical argumentation constructs have been used namely, Toulmin's (1958) Argumentation Pattern (TAP) and Ogunniyi's (1995) Contiguity Argumentation Theory (CAT).

The study was also premised on socio-cultural constructivism which has arisen from the works of Piaget, as stated by Kitchener (1986) and Vygotsky (1962) and their associates as well as meaningful learning as espoused by Ausubel (1968). It also sought to find out whether age and gender influenced the learners' understanding of these concepts.

The study adopted a quasi-experimental design, in which two comparable groups were used. One was the experimental group, while the other one was the control group. Both qualitative and quantitative research methods were employed in gathering data. The instruments included a Water Pollution Achievement Test (WPAT) that was used to quantitatively assess the learners' conceptions of water pollution, two qualitative instruments: an argumentation-based instructions questionnaire and a focus group interview were used. All the instruments were in Afrikaans and translated for the purpose of reporting and reflection in this thesis. The only difference between the two groups was that the experimental group (E group) was exposed to Argumentation Based Instruction and the comparison group (C group) to the traditional lecture method. Data analysis was done quantitatively and qualitatively.

The findings of the study suggest that:

- The pre-test scores of the two groups indicated that: (i) the groups were comparable; (ii) they demonstrated valid conceptions of water pollution and (iii) some learners had traditional knowledge**.**
- By means of statistical analysis it was determined that at post-test the E group outperformed the C group in terms of the WPAT. Their responses (E group) showed a deeper understanding of the conceptions and magnitude of the problem of water pollution.

Although the instructional model (ABI) seemed to be effective in improving E group learners' conceptions of water pollution, one acknowledges the fact that due to the very limited period and number of subjects involved, it is reasonable to suggest that further in-depth research into its effectiveness be carried out on a much larger scale and over a longer duration.

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10 KEY WORDS

1. Argumentation-based instruction
2. Grade 10 learners
3. Toulmin's argumentation pattern

4. Contiguity argumentation theory

4. Constructivism
5. Quasi-experimental design

6. Case study

7. Water pollution

8. New curriculum

9. Science

10. Indigenous knowledge systems

ABBREVIATIONS USED IN STUDY

C2005	-	Curriculum 2005
CAT	-	Contiguity Argumentation Theory
ABI	-	Argumentation-based instruction
DOE	-	Department of Education
IKS	-	Indigenous Knowledge Systems
LO	-	Learning Outcomes
NCS	-	National Curriculum Statement
OBE	-	Outcome Based Education
RNCS	-	Revised National Curriculum Statement
SIKSP	-	Science and Indigenous Knowledge Systems Project
TAP	-	Toulmin's Argumentation Pattern
WCED	-	Western Cape Department of Education
WPAT	-	Water pollution achievement Test

CHAPTER 1
INTRODUCTION

1.1 Preamble

It seems as if education is failing a large part of its population particularly learners from the previously disadvantaged communities. The ANC led government since its coming to power in 1994 has made concerted effort to redress the gross dichotomy created during the apartheid era in the South African education system. A notable effort in this regard has been the implementation of an Outcomes-Based Education (OBE) curriculum known as Curriculum 2005. But good as the intention of the new curriculum might be, the human and material resources needed to implement such an ambitious inquiry- and activity-based curriculum are well beyond the reach of many a previously disadvantaged school. The new curriculum demands the development of process skills among learners. It also expects teachers to integrate learners' indigenous knowledge with school science so as to make school experience relevant to life outside the school environment. How does a teacher like me schooled in the orthodox expository form of teaching transform his practice overnight without further training?

My experience as a science teacher in a school located in a disadvantaged area of Cape Town for a number of years convinced me that unless some drastic steps were taken to enhance teachers' instructional practices the learners would continue to underperform in science. It was on account of this that I enrolled in a Master's in Science Education to upgrade my academic and my professional practice. It is worth noting that in spite of numerous efforts made by government to improve results in high schools, the percentage and quality of matriculation passes are still below expectation. The need to close the yawning gap between curriculum expectation and learner performance remains a perpetual challenge. Yet the closeness between the two invariably serves as a useful barometer to determine a country's quality of education. In situations where learners are apathetic towards science education in particular, it is doubly difficult to motivate such learners to change break the vicious cycle of under-performance. I shall elaborate on this later.
In my own experience, our learners are still struggling to fully comprehend and assimilate the curriculum content. Examinations continue to be a daunting task. The classroom environment has not changed much. Besides this is the enormous amount of administrative duties that clutter a

teacher's desk with respect to demands of the new curriculum. The traditional method of chalk and talk permeates every lesson. This study is an attempt to investigate the shift to a more active role for learners based on a dialogical argumentation instructional approach underpinned by Toulmin's Argumentation Pattern (PAT) as espoused by Erduran, Simon & Osborne (2004) and Ogunniyi's (2002) Contiguity Argumentation Theory (CAT). However, before elaborating on this instructional approach, it is expedient to provide some background to the study.

1.2 Background

Before 1953 mission schools provided almost all of the education which was available for blacks. In 1948 the National Party came to power, and introduced the policy of apartheid. The Eiselen Commission was appointed to make plans for 'the education of the natives as an independent race'. This spelt the end of mission control over African Education. During the apartheid era from 1948-1991 (Fataar 1997) unfair biased education policies saw many underprivileged (non-whites) pupils fall to the wayside. A few situations are illustrated. The per capita expenditure for the different population groups reflects their inhumane intent.

Table 1: Per capita expenditure on education in South Africa

Year	African	Coloured	Indian	White
1975-6	R42	R140	R190	R591
1977-8	54	185	276	657
1980-1	139	253	513	913
1982-3	146	498	711	1211

(From: Christie, 1985, p.98)

It is clear from the above table that a lot more money was spent on whites than on the other groups. In 1982-3, the ratio of African to white spending was 1:8,27 that is eight times more money was spent on every white child than on every African child.

The drop-out rate for blacks was consequently very high compared to those of whites (school attendance, for whites was compulsory up to grade 10). Exiting school early merely favoured the oppressors' political and economic agenda. The four years of education which most black school attendees received would prepare them for unskilled jobs and lower social positions

(Christie, 1985). The better paid jobs were reserved for the privileged whites, affording them better socio-economic circumstances (Badat, 1991). High pupil-teacher ratios meant overcrowded black schools. Individual support for learners in the teaching and learning process were almost non-existent.

This vicious cycle of depriving the masses basic human rights was aggressively opposed. Many uprisings occurred for example, 1976, 1980 and 1985, which was ignited in June 1976. Schools and other educational institutions became the battlefield against an unfair, unjust and inferior system. The children showed clearly that they were rejecting the imposition of Afrikaans as medium of instruction. But the real causes of the uprising were the racism and poverty that they were experiencing. An outcry for "liberation before education" was the common theme. Even though the efforts to topple apartheid seemed to bear no fruit at the time, slow but steady progress was made. Class boycotts exacerbated the already poor performances of learners in the disadvantaged communities. The consequences of this philosophy of life in terms of learners' general apathy to formal education are still felt even after nearly two decades into the new era.

As stated earlier, the newly democratic South Africa opted for an Outcomes Based Education System (OBE, 1997), replacing the outdated segregating Christian National Education Policy (CNE). A new policy meant new teaching strategies. The Department of Education provided little, if any, training. Teachers found themselves at their wits end trying to cope with new terminology, assessment strategies and greater curricular demands. Instead of increasing the number of teachers to lower the pupil-teacher ratio the number was decreased.

Right sizing of schools through educators' redeployment forced experienced teachers out of the system (Chisholm, 1997). Voluntary severance packages and rationalization saw many teachers leave the profession. These and other contributing factors placed enormous pressure on those who remained in teaching. The implementation of Curriculum 2005 (C2005) demands the teaching of a new Science-Indigenous Knowledge Systems (IKS) curriculum. One of the main reasons for introducing C2005 as stated by Ogunniyi (2007a, p963) is as follows: "IKS reflects the wisdom about the environment developed over the centuries by the inhabitants of South Africa."

Although necessary, the unilateral introduction of C2005 was met with opposition. Critics, such as (Jansen, 1997; Julie 1997) reasoned that it was doomed to fail. Jansen (1997) argued that introducing the new curriculum was politically motivated. Julie's (1997) agreement with Jansen was based on, amongst others, teachers' non-involvement, the lack of sufficient clarity of what is a Learning Outcome and whether or not this can be predetermined etc. Teachers' familiarity with school science compared to a fairly unknown IKS curriculum and the need for new teaching strategies caused an upheaval in the teaching arena (Jansen & Christie, 1999; Ogunniyi 1997, 2004). In depth training, funded and supported by Department of Education (DOE), to facilitate the IKS-science curriculum could have had a positive impact on teachers' stances towards the new curriculum (Ogunniyi, 2007a, 2007b). According to MacDonald and Walker (1976) curriculum development is not an easy endeavor and hence relevant stakeholders must be engaged to minimize opposition. In spite of all the vociferous objections to the new curriculum it has become a reality and needs every effort to make it successful.

High school learners from disadvantaged communities are de-motivated because many matriculants are either unemployed or do menial jobs with little remuneration. Their results are not good enough in order for them to gain access to a tertiary institution or to obtain a bursary to further their studies. Consequently learners at our school are generally not very eager. The negative socio-economic circumstances cause many learners to leave school prematurely. Corroborating this negative spiraling trend Ogunniyi (1995) found that studying a demanding school subject such as science no longer appeals to the learners' intellectual interest. If learners' attitudes towards education could be changed a marked difference in their academic performances would be possible.

According to Fish (1996) science seems to be unpopular because it is boring, irrelevant and difficult. It is boring because learners are merely passive observers or listeners. Class work consists more of drilling exercises than actual problem-solving and there is little time for discussion around a theme or an interesting idea. He suggested ways of popularising science and technology using means such as resource centres, interactive science centres, science expo's etc. These suggestions could however prove to be effective or otherwise depending on the way they are implemented. In the more literate societies interactive museums have been closely integrated into the social life of the community. For instance, in Europe and the U.S.A. it is not uncommon to see the whole family spending most of the weekend in a botanical or zoological gardens, amusement parks or science museums. In this regard the context and language of the home and that of the school have been greatly synchronized.

Poor teaching methods utilized by teachers, especially inadequate training (Muwanga-Zake, 2000; Tyobeka, 2000) and weak knowledge of the discipline have contributed to learners' underperformance in science.

The problems schools encounter daily in terms of overcrowded classrooms, lack of laboratories, poorly qualified teachers and others, definitely impact on the performance of learners. Matriculation results in black schools are poor with mathematics and science being the worst subjects. This situation was highlighted in a media report: "SA falters as science slips to the bottom of the class (Sunday Times, 29/9/96)". Although the recently released matric results for 2010 augurs well for the future, there is need for caution as one does not know if this is related to the rubrics of excessive marks readjustment as some have claimed or is the true picture of learner performance. Time would tell. However, the maintenance of this positive trend in future matric results would confirm the actual situation of things.

1.3 Background of the school under study.

I have been teaching for several years at the school involved in the study. The school is situated in a sub-economic housing scheme area. It was the only high school, in the area, when it was built and consequently attracted many talented learners. The school has a proud history of excellent academic as well as sporting achievements. However, over the last decade we have seen the gradual decline in academic achievements. The school had been declared an NSLA (National strategy for learner attainment) school, due to under-achievement. Learners appear to suffer from a form of shortsightedness regarding their future careers. Many of the problems alluded to earlier are still prevalent in the community. Poverty, unemployment, early termination of schooling, shack-dwelling and related survival ethos and other social problems are rife. The school encounters typical problems of absenteeism, alcohol use, drug abuse among learners and it lacks a culture of learning. Discipline is begging to be enforced. Learners are apathetic towards education and this is evident from the fact that home work is not done.

1.4 Motivation for the study

The question can be asked: why should learners learn science? It is common practice the world over that science is accorded high status, and allocated considerable resources, Driver et al (1996). Science teaching has social restructuring capabilities. Under performance in science have serious implications for scientific and technological human power development, as is well known, science plays a significant role in the socio-economic development of a country (Ogunniyi, 1998). A scientifically literate population is more likely to have a positive attitude towards science and technology, and to be more supportive of scientific technological developments than one that lacks such an attitude (OST 1993).

Research done at the University of the Western Cape under the auspices of The Scientific and technology Literacy Project (STLP) found that both primary and secondary learners lacked the cognitive readiness to pursue careers in science (Ogunniyi 1999). According to Ogunniyi (1986) science is an attempt by human beings to organize their experiences about nature into meaningful systems of explanations. To make science a relevant school subject Curriculum 2005 (C2005) or simply the new curriculum encourages teachers to include (IKS), together with science, that is prevalent in the previously marginalized/disadvantaged communities. This objective is in agreement with Barton's (1996) view of science education namely, catering for the interests and cultural backgrounds of learners.

Historically science has been seen as a body of unequivocal and uncontested knowledge (Simon, et al., 2006). However, Habermas (1971) says that: "scientific truth does not coincide with absolute truth in its metaphysical sense". It is therefore imperative that we include an alternative view to science, i.e. IKS. The new curriculum constructs argumentation and classroom discussions as critical aspects of school science and the development of process skills. It is clear from research that a curriculum that encourages discussion, argumentation, dialogue, and reflection is more effective for promoting understanding of the Nature of Science (NOS), IKS, or both systems (e.g., Erduran, Simon, & Osborne, 2004; Ogunniyi 2004; Simon et al., 2006). However (Kuhn, 1991) asserts that argumentation discourse does not come naturally and that it is acquired through practice, i.e. it must be taught.

The Physical Science Framework consists of three Learning Outcomes (LO). LO3 links the Nature of Science and its relationship to Technology, Society and the environment. The grade 10 Physical Science syllabus makes provision for the teaching of the water cycle. The fact that scientists are turning to indigenous knowledge users for assistance indicates that there is a need for science and IKS to co-exist (Corsiglia & Snively, 2001). In Ogunniyi's work (2007a, 2007b) it is clear that through a Practical Argumentation Course (PAC), teachers' views regarding IKS and science were greatly altered. It is consequently my intention to research the effect of argumentation-based instruction on grade ten learners' understanding of the causes of pollution at a river site. In other words, this study seeks to investigate how an Argumentation-Based Instruction (ABI) as a pedagogic tool could help enhance learners' understanding of water pollution.

Africa is a dry continent and therefore every effort should be made to preserve our natural water resources. Water is essential to all life forms both fauna and flora depend on it for their existence. A news paper article sparked my initial interest, and after investigating the problem of water pollution, the enormity of the situation was discovered. A greater demand for clean water resources due to a fast growing urban population meant proper water management. The overcrowded urban areas resulted in shortages in amongst others sanitation services that exacerbated the problem of water pollution. The City of Cape Town municipality instituted water restrictions from 2008 to regulate the usage of water. These and other measurements, such as high water tariffs, were put in place to preserve our water resources. Identifying the sources of pollutants is significant in light of the water shortages experienced within the South African borders in the recent past, as it enables the implementation of appropriate actions to manage water resources. If preserving our water resources is crucial for our existence then the future generations should now be taught to appreciate what is available.

The seven critical outcomes in the Revised National Curriculum Statement for the natural sciences are:

- Identify and solve problems and make decisions using critical and creative thinking.
- Work effectively with others as members of a team, group, organization and community.
- Organize and manage themselves and their activities responsibly and effectively.
- Collect, analyze, organize and critically evaluate information.
- Communicate effectively using visual, symbolic and/or language skills in various modes.
- Use science and technology effectively and critically, showing responsibility towards the environment and the health of others.
- Demonstrate an understanding of the world as a set of related systems by recognizing that problem solving contexts do not exist in isolation. (RNCS 2001).

The challenges posed by the list of outcomes above imply the adoption of a new instructional approach that expects learners to assume a greater responsibility for their own learning. They also imply that teachers would have to play the role of a facilitator than that of transmission of a host of information to be committed to memory by learners. It is in this regard that an Argumentation-Based Instruction (ABI) was considered more appropriate for the study than the traditional chalk-and- talk approach.

1.5 Problem statement

This study used ABI that created an environment for group work, participation, critical thinking, communication etc. Learning Outcome 3 envisages the interrelationship between science, society and the environment. Traditional education requires the memorization and reproducing of scientific facts, the new curriculum however extends learning to include relevant IKS materials and the development of process skills including critical thinking and problem-solving skills among others. The high failure rate of black learners in matriculation examination in physical science has been attributed to many factors, such as:

- Ineffective teaching methods due to teachers not understanding how children learn.
- Textbooks, which are not easily accessible to learners.
- Historical issues e.g. poorly qualified teachers or under-qualified teachers still exists.
- The chaotic state of many township schools.

The above constraints among others hamper classroom activities on a daily basis and have an overall negative effect on their performance in the examinations. In such a situation the additional skills presumably needed in the work place and which the new curriculum seeks to capture can thus be seen as a tall order indeed. As Simon et al (2006) has argued a curriculum demanding learners to demonstrate critical thinking skills and the like requires a drastically different instructional strategy than the status quo.

1.6 Purpose of the study

The aim of the study is to determine the effectiveness or otherwise of argumentation- based instruction (ABI) on grade 10 learners' understanding of water pollution at a river site. More specifically, the study attempts to:

- Determine learners' prior knowledge of water pollution.
- Determine the effectiveness or otherwise of argumentation- based instruction relating to environmental issues.
- Determine whether or not the use of argumentation-based instruction was more beneficial to learners' understanding of water pollution than the traditional lecture method.

Among others, some of the reasons why ABI as opposed to the lecture method was adopted for the study include:

1. Traditional teaching method tends to exclude learners' life-world experiences to a great extent in that it tends to limit learners to play only a passive receptive role. In this regard, learners are assumed to come into the science classroom tabula rasa.
2. ABI allows learners to externalize their thoughts, clear their doubts and even change their conceptions of various phenomena.
3. Research studies have indicated that dialogical argumentation instruction tends to encourage the co-construction of concepts or ideas among learners as they participate more actively in groups than the whole class (Erduran, et al, 2004; Ogunniyi, 2004, 2007 a & b; Simon et al, 2006).

1.7 Research Questions

In pursuance of this purpose of the study answers will be sought to the following questions:

- What conceptions of pollution do grade 10 learners hold?
- What process skills do grade 10 learners use to perform cognitive tasks on water pollution?
- Are the learners' conceptions of water pollution related to gender, age or socio-cultural backgrounds?
- Is there any difference in the performance of learners exposed to an argumentation- based instruction and those who have not been so exposed?

1.8 Theoretical Framework

As already indicated the current educational system does not provide the expected matriculation results, especially in the former DET (Department of Education and Training) and HOR (House of Representatives) schools. In fact we find that from grade 1 – 12 learners experience learning difficulties. Mathematics and science seem to be a major obstacle in learners' performance. Due to frustrating learning experiences many learners leave school prematurely. Poor socio-economic conditions, lack of parent involvement, peer pressure etc. are some of the many reasons for learners' disillusionment with education practices. They are viewed as empty boxes that need to be filled and consequently the transmission method is still preferred by many teachers. It could also be that teachers cling to this traditional teaching method, because of a lack of training that should have been organized by the Department of Education (DOE) and perhaps due to teachers' apathy. Time constraints and the emphasis on results especially matriculation results still dominates classroom practices.

Traditionally teachers hold the view that:

- Science knowledge is unproblematic.
- Science provides right answers.
- Truths in science are discovered by observing and experimenting.

These views have been explored in a number of commentaries (e.g. Chalmers, 1976). Knowledge is transmitted from teacher to learner, this teaching strategy avoids discussion.

Learners' knowledge is not appreciated or valued. Memorizing science content and reproducing it in examination/tests deem certain learners more suitable than others. It therefore excludes a vast number of students on the basis of a skill they are weak in. There is evidence that memorized knowledge is not well understood. Fensham (1985) has argued that this is unhelpful to learning in science for all students.

1.8.1 ***Argumentation based instruction***

Argumentation is a form of discourse that needs to be appropriated by children and explicitly taught through suitable instruction, task structuring, and modeling (e.g. Mason, 1996). Science is not merely a collection of facts agreed upon, but evolves through disputes, conflicts and arguments (Kuhn, 1962). If argument is important for learning, then teachers need to be trained in its application, as was done by Ogunniyi (2007).

The analysis of argumentation discourse is a means to determine the quality of an argument. A suitable analytical framework is Toulmin's (1958) model referred to as Toulmin's argument pattern (TAP).

Erduran et al (2004, 918) explains the TAP as follows:

TAP illustrates the structure of an argument in terms of:

- an interconnected set of a claim
- data that support that claim
- warrants that provide a link between the data and the claim
- backings that strengthen the warrants
- Rebuttals which point to the circumstances under which the claim would not hold true.

The authors state that the TAP poses difficulty in its application. It is not easy to distinguish between claim, data, warrant and backing. How the quality of an argument can be measured by TAP is not understood. They further argue it is not clear whether TAP could be used as quantitative and qualitative indicator of argumentation over time (Erduran et al, 2004). This was overcome by looking for rebuttals in arguments. The strength of rebuttals signals the quality of arguments. They classified an argument as either low level or high level depending on the absence or presence of a rebuttal (Erduran et al., 2004:921). Working within the confinements of a set curriculum and to include alternative activities to facilitate argumentation calls for careful planning.

1.8.2 Contiguity Argumentation Theory

But useful as TAP is in analyzing learners' explanations of phenomena, it is limited as a means for exploring and analyzing equally important worldviews of learners based on their daily experiences, especially those not easily amenable to scientific explanations. The Contiguity Argumentation Theory (CAT) according to Ogunniyi (2005) construes learning as a dynamic process which changes from one context to another. It is a dialogical theoretical construct which depicts the way learners go about reconciling conflicting schemata which tend to arise between what learners believe and what they are taught in the science classroom. It assumes that the learner's cognitive structure consists of three basic worldview schemata: traditional beliefs (indigenous knowledge), commonsense-intuitive knowledge and science. The three schemata are in a state of dynamic flux and all are activated by contextual circumstances in which a person finds himself/herself as well as the interest to be served. These constructs coalesce in a variety of ways as an adaptive mechanism. Hence, a worldview which is dominant in a given context may become suppressed in another context or may be assimilated into a more dominant worldview. What determines the worldview mobilized at a particular instance is therefore the arousal context (Ogunniyi & Hewson, 2008). Ogunniyi and Hewson contend further that:

> CAT holds that claims and counter-claims on any subject matter within (or across) fields (e.g., science and IKS) can only be justified if neither thought system is dominant. There must also be valid grounds for juxtaposing the two distinctive worldviews within a given dialogical space. The role of such a dialogical space is to facilitate the process of re-articulation, appropriation, and/or negotiation of meanings of the different worldviews. Students must therefore be able to negotiate the meanings across the two distinct thought systems in order to integrate them. (Ogunniyi & Hewson, 2008:162).

More would be said in chapter 2 how CAT was selected as part of the theoretical framework for this study.

1.8.3 Social Constructivism.

Our earliest forms of learning (infancy to pre-school stage) occur mainly through social interactions (with our parents, siblings and others), these learning instances occur naturally. This natural process is interrupted with the introduction of formal schooling and its obsession with discipline, a set curriculum and report cards.

Argumentation-based instruction assumes teacher intervention, learners' participation, and interaction between them, reflection and the exchange of ideas. Learners hold previously constructed concepts and skills as espoused by Gagne (1970). This prior knowledge serves as building blocks for new concepts and skills.

The term constructivism encompasses a wide variety of theoretical positions (Good, 1993; Geelan, 1997) and has been variously used to refer to views about learning, teaching curriculum development and teacher professional development. Constructivist theories do not necessarily imply constructivist practices. Processes of "eliciting, clarification, and construction of new ideas take place internally, within the learner's own head" (Millar, 1989: 589). However, the constructivists' ideas of learning render teaching tools that might help learners' attempts of conceptual reconstruction (e.g. they nurture students ideas and views, allow them to explore, and stimulate their learning processes).

Posner et al. (1982) argue that new learning can be brought about only when learners are dissatisfied with their current beliefs/understanding and have ready access to a new or better idea. In a multi-cultural classroom it is inevitable that different belief systems, language, religion etc. will impact individual and cooperate learning. Every culture has its own Indigenous Knowledge System (IKS); every learner can therefore make a fruitful contribution to an argumentation-based instruction. Driver et al. (1994:7) suggests that: "If knowledge construction is seen solely as an individual process, then this is similar to what has traditionally been identified as discovery learning" by Jerome Bruner. This would be contrary to the outcomes of argumentation-based instruction alluded to earlier. The inclusion of IKS into the science curriculum and IKS being influenced by socio-cultural issues, suggests a shift from constructivism to social constructivism. Teachers need to foster an atmosphere where learners will feel free to participate in a discursive methodology.

Vygotsky's (1962) work seems to serve as a useful response to a call for a re-evaluation of the constructivist framework. He focused on how children learn from participation in activities with other people. He says:

> Any function in the child's cultural development appears twice, or on two planes. First it appears on the social plane, and then on the psychological plane. First it appears between people as an interpsychological category, and then within the child as an intrapsychological category…Social relations or relations among people …underlie all higher (cognitive) functions and their relationships. (Vygotsky, 1978:57).

The argumentation based instruction (ABI) might give children the chance to the type of participation Vygotsky is talking about. Learning involves a passage from social contexts to individual understanding (Vygotsky, 1978). Learning is not bound to the school environment, it happens at home, in communities and other spheres they engage in. In a class activity many discussions occur. If discussions are not feared, an exchange of ideas between teacher and learners takes place and from these interactions individual thinking emerges. This is what Vygotsky (1962) means by the notion of interactions as existing on the social plane.

Teachers need to make scientific knowledge available on the social plane of the classroom, supporting students as they try to understand it. The gap between teaching and learning can be bridged using his concept of Zone of Proximal Development (ZPD) (Vygotsky, 1978). The ZPD provides a measure of the difference between what the students can achieve working alone and what can be done with the assistance of teachers and other more capable learners. It is in the ZPD that scaffolding (Wood, Bruner and Ross, 1976) can be used to adjust learners' participation from being a spectator to participant. Scaffolding is a process whereby learners advance with the assistance of teachers and more competent peers, until they can function independently. It is evident that knowledge is not merely handed on. Rather, it is co-constructed through social interaction.

1.8.4 Socio-cultural perspectives of science teaching.

Indigenous knowledge systems (IKS)

Historically, western education, through the instrumentality of school science, presents science as based largely on a mechanistic worldview. The indigenous knowledge systems on the other hand, present essentially an anthropomorphic worldview. Of the school subjects that were imposed on the indigenous learners in the colonial schools, science has been taught as a culture-free subject. According to Ogunniyi (2008, p5) 'IKS is a way of knowing and interpreting experiences peculiar or innate to particular cultural groups'.

Several times a week they cross from the culture of the home, over the border into the culture of science, and then back again (Department of Education 2002, 11±12). There is a wealth of knowledge in every people group which is not easily accessible to other groups for reason of differences in language and other cultural differences.

Various studies have adopted a cultural view towards science education in that it portrays science teaching as a cultural activity (Aikenhead, 1996; O'Loughlin, 1992). School science is an attempt at enculturation or assimilation of learners. To Aikenhead (1996) and Adams (1999) enculturation is a process whereby a learner accommodates school science into his/her cosmology whilst retaining his/her sense of identity. Assimilation on the other hand, is the process of subsuming his/her worldview to that of science. Learners move intellectually from their life worlds (traditional worldview) to that of school science a process known as cognitive cultural border crossing, Aikenhead & Jegede (1999). Whether this transition is smooth or impossible depends on the degree of cognitive conflicts between the two worlds.

Jegede (1995) has proposed the Collateral Learning Theory as a mechanism to explain how a student harmonizes the conflict resulting from a traditional worldview and that of science. He asserts that a student in a science classroom will construct scientific concepts side by side, and with minimal interference and interaction, with their indigenous concepts. Ogunniyi (2002) posited the Contiguity Learning Theory (CAT) as an explanatory model for cognitive border crossing. CAT depicts border crossing as a dynamic rather than a fixed process. More details of this theoretical construct in which the study is situated are presented in chapter 2.

1.9 Hypothesis

To answer the research questions the following null hypotheses were posited for testing:

- Grade 10 learners do not hold valid conceptions of water pollution.
- The learners' performance on water pollution will not be influenced by their age or gender.
- There is no significant difference between learners exposed to argumentation-based instruction and those not so exposed.

1.10 Significance of the study

It is hoped that the findings of the study will:

- Contribute to efforts at identifying the difficulties that learners have on water pollution.
- Identify some of the alternative conceptions about water pollution that learners hold thus providing the necessary platform for remedial instruction.
- Provide useful information about the effectiveness or otherwise of argumentation-based instruction.

1.11 Limitations of study

One cannot spend too much time on one topic as we work in a fix curriculum with prescribed pacesetters. Emphasis on examination readiness still dictates time frames. The learners poor academic performance suggests that they are either unmotivated or suffers from poor self esteem. Many teachers are reluctant to help as they are already overburdened with administrative duties demanded by the new curriculum and associated assessment protocols. Despite these limitations effort was made to determine the effectiveness of ABI on grade 10 learners' conceptions of water pollution. It was hoped that the experience gained from the study would prove informative and useful to efforts directed at implementing the new curriculum.

CHAPTER 2
LITERATURE REVIEW

2.1 INTRODUCTION

Historically, the teachers' role in the science classroom during the apartheid era in South Africa was to present prescribed curricular materials to learners. Subsequently, learners' worlds of knowing were ignored, and learners were instead expected to accept the teacher's realm of meaning making. As a result of this form of schooling, learners have become silent role players, assuming the passive and constrained roles assigned to them by their teachers. Learners felt compelled to leave their world outside the school and so as to enter the teacher's world. This setting has led to the usual disparity between learners' personal ways of knowing and the teacher's way of academic knowing. This scenario further restrains effective communication between the learner and teacher and hence, it is not too difficult for one to see why many learners are eager to abandon studies in the sciences or their bad academic performances in science because what they learn in the science classroom does not coincide with their life worlds outside the school premises. In other words school learning is not meaningful to them. But before considering what meaningful learning is, it is apposite to consider what we mean by learning.

What is learning? Some learning may be easy to discern, such as an individual acquiring a new vocabulary, counting correctly, identification of certain physical features, etc. while forms of learning are not so obvious in that they are acquired indirectly or after much reflection on an experience. Many skills are learned through the social interplay with others.
Hilgard and Bower (1975:2) assert that:

> Learning is the process by which an activity originates or is changed through reacting to an encountered situation, provided that the characteristics of the change in activity cannot be explained on the basis of native response tendencies, maturation, or temporary states of the organism (e.g., fatigue, drugs, etc.).

Learning with understanding (Wittrock, 1974) focuses on the proposition that learners must themselves actively construct meaning from sensory input. Piaget, too, considered that knowledge is constructed by the individual as he/she acts on objects and people and then tries to make sense of it all (Kamii and De Vries, 1978).

If one adopts a constructive view of learning, the importance for science teachers of understanding children's science becomes very clear. Teachers should adopt a student dominance assumption (Fensham, 1980) in their planning. However, many science curricula adhere to the notion of behaviourism. Behaviourism, assumes a tabula rasa notion of learning i.e. the learner has a blank mind which can be filled by the teacher. Learners assume a passive role during teaching and learning, whereas the teacher rumbles along. Its popularity with the general public as a model for learning is evident in much of the media criticism of education today (Lewington and Orpwood, 1993).

The new South African curriculum suggests that for learning to be meaningful to most learners, especially learners from traditional African communities there is need to include knowledge based on learners' Indigenous Knowledge Systems (IKS) in the science classroom. The underlying assumption of the new curriculum is that for meaningful learning to take place among learners they must see some relationship between the knowledge they bring into the classroom and what they learn in the science lessons. Otherwise school learning might alienate them from their daily experiences in their respective communities. In other words, the two schemata namely, science and IKS will have to interact, be experienced and become associated together. This is known as the principle of association by contiguity and accepted by some researchers e.g. Guthrie and Tolman (as cited by Ogunniyi, 1995). The success or otherwise of instruction to a large extent, depends on the relevance of what is taught to their daily lives. Hence, a student might partially or totally accept new knowledge or keep his/her own ideas and what is taught in a science class side by side without much interaction. This is what Jegede (1995) calls "collateral learning." However, Ogunniyi (1988) contends that a form of "harmonious dualism" does take place especially when learners construe both science and indigenous knowledge (IK) as complementary. The harmonious dualism theory was elaborated further to the Contiguity theory (Ogunniyi, 1997) which serves as an explanatory model for "cognitive border crossing" that occurs between learners' IK and school science (Aikenhead and Jegede (1999). I shall provide more detail on this in sub-section 2.2.

According to Ellerton (1999), theories have tended to be based on social constructivist ideas emanating from Vygotsky and into situated cognition. This has resulted in a holistic view of culture that encompasses language. This view of the all-encompassing nature of culture is illustrated in a definition of culture by Mousley and Clements (1990) which clearly defines it as the overriding concepts embracing language. To Mousley and Clements (1990):

> The term culture generally refers to a social heritage–those characteristic behaviours which are transmitted from one generation to the next. While the notion of culture includes collective mental artifacts such as symbols, ideas, beliefs and aesthetic perceptions … it also embodies distinctive forms of discourse … (p.398).

2.2 Border Crossing

Border crossing is the transitioning of learners, back and forth, from their cultural environment of family and their peers, into the subcultures of science and school science (Aikenhead, 1996). It is an experience that people acquire as they move from the familiar milieu into one that alienates them from their natural worlds and worldviews.

Like science, the traditional worldview system of the learner is based on certain fundamental assumptions about reality. But unlike science which is based on a mechanistic explanatory model IK or the learner's traditional worldview is based on an anthropomorphic and a monistic view of the universe (Ogunniyi, 1988). The implication is that the scientific and traditional worldviews are based on different assumptions and hence, the coming together of both systems of thought is likely to result in cognitive conflict. This translates into a science classroom that appears alien to learners, especially to those coming from a non-western culture. Learners struggle to reconcile their worldviews with those of school science. Solomon (1983a) noted that life-world knowing contrasted and co-existed with science-world knowing. Learners cross the physical borders coming into a science classroom, but the cultural borders may not be easily crossed (Hennessy, 1993, p. 9). Their life-world experiences are distinct from that of science-world.

Culture is defined by Phelan, Davidson, and Cao (1991) as: "the norms, values, beliefs, expectations, and conventional actions of a group" (as cited by Aikenhead, 1996, p. 8). School science traditionally attempts to enculturate or assimilate students into the subculture of science (Aikenhead, 1996). It is a foreign science forced onto them. The transition is very different for various learners. Phelan et al.'s (1991) data suggested four types of transitions (from life-world to science-world): “congruent worlds support smooth transitions, different worlds require transitions to be managed, diverse worlds lead to hazardous transitions, and highly discordant worlds cause students to resist transitions which therefore become virtually impossible” (as cited by Aikenhead, 1996, p. 14).

Research findings in Western world (Costa, 1995; Cobern, 1994b; Layton et al. (1993, Ch. 8) and non-Western settings (Baker and Taylor, 1995; George, 1988; Jegede, 1994; Maddock, 1981; Ogawa, 1986; Pomeroy, 1994; Swift, 1992) are similar regarding what science should be taught. A science found in learners’ social environment is one that acknowledges and values their worldviews. The question is, can this type of science be easily attained? Ogunniyi (2007a) found that a practical argumentation course, as a teacher training programme can serve the purpose of: “enhancing teachers’ understanding as well as increasing their awareness of the need to implement a Science-IKS curriculum in their classrooms” (p963). His contention is that a dialogical argumentation classroom context can be used as an opportunity for learners to express themselves freely, externalize their thought, clear their doubts and even change their views about diverse phenomena.

2.2.1 Collateral learning Theory

According to Jegede (1995) collateral learning generally involves two or more conflicting schemata held simultaneously in long-term memory. There are variations in the degree to which the conflicting ideas interact with each other and the degree to which conflicts are resolved. Four types of collateral learning were proposed, i.e. parallel, secured, dependent and simultaneous collateral learning.

- In parallel collateral learning, the conflicting schemata do not interact at all.
- In secured collateral learning the conflicting schemata consciously interact and the conflict is resolved in some manner.
- In dependent collateral learning, the schema from one worldview or domain of knowledge challenges another schema from a different worldview or domain of

knowledge, to an extent that permits the student to modify an existing schema without radically restructuring the existing worldview or domain of knowledge.

- Simultaneous collateral learning fits between parallel and dependent collateral learning on the spectrum described above. It is a situation in which learning a concept in one domain of knowledge or culture can facilitate the learning of a similar or related concept in another milieu.

For many students, learning science meaningfully often involves cognitive conflicts of some kind. Therefore, meaningful learning often results in parallel, dependent, or secured collateral learning. According to Cobern (1996, p. 604), students should develop "a new or modified understanding of the world based on new concepts and ideas but concepts and ideas interpreted in the light of culturally grounded meaning."

2.2.2 Contiguity Argumentation Theory (CAT)

The Contiguity Argumentation Theory (CAT) was selected as part of the theoretical framework for the study because it is amenable to explanations that do not fall readily under syllogistic reasoning on which TAP is based. Ogunniyi (2005) construes learning as a dynamic process which involves a reconciliation of various worldviews. It is a dialogical theoretical construct depicting the way learners go about reconciling conflicting different schemata. It assumes that the learner's cognitive structure consists of three basic worldview schemata: traditional beliefs (indigenous knowledge), commonsense-intuitive knowledge and science. The three schemata are in a state of dynamic flux and all are activated by contextual circumstances in which an individual finds him/herself or the interest to be served.

According to Ogunniyi and Hewson (2008):

> CAT holds that claims and counter-claims on any subject matter within (or across) fields (e.g., science and IKS) can only be justified if neither thought system is dominant. There must also be valid grounds for juxtaposing the two distinctive worldviews within a given dialogical space. The role of such a dialogical space is to facilitate the process of re-articulation, appropriation, and/or negotiation of meanings of the different worldviews.

> Students must therefore be able to negotiate the meanings across the two distinct thought systems in order to integrate them. (p.162).

They state further that CAT recognizes five categories of contiguous associations between two or more conflicting schemata. These categories as depicted below are dominant, suppressed, assimilated conceptions, emergent conceptions, and equipollent conceptions.

- A conception might be dominant or suppressed depending on which thought system is appropriate to a given context.
- An emergent conception arises when an individual has no prior knowledge of a given phenomenon.
- An equipollent conception occurs when two competing ideas or worldviews exert comparably equal intellectual force on an individual. In that case, the ideas or worldviews tend to co-exist in his/her mind without necessarily resulting in a conflict e.g., creation theory and evolution theory.
- However in a case where the new idea is preferred to an old one is what they call assimilatory.

Ogunniyi has contended further that, when two cultures or systems of thought meet, their co-existence is facilitated through conceptual appropriation, accommodation, integrative reconciliation and adaptability (Ogunniyi, 1988, 1997, 2004). Also as Ogunniyi and Ogawa (2008) have contended there are several worldviews present in the science classroom and unless the educator is aware of this he/she might only help in alienating learners further from the study of science. A reason for this is that learners feel that their beliefs, IKS-based knowledge and daily experiences at home have no relevance to what they learn at school. As a result learners might play a sort of game by giving the teacher what he/she wants to fulfill examination requirements while in the main they see very little value for it outside the school environment. Such compartmentalization of knowledge is what Jegede (1995) parallel collateral learning. What CAT attempts to do has been to establish some intellectual bridge between distinct knowledge systems e.g. science and IKS by construing such systems as dynamic and context bound. CAT therefore does not construe science and IKS as “polar opposites in a linear theory of social change” (Ogunniyi, 1988:2) but as complementary representations of human experiences each one significant for a given context (Ogunniyi, 2007 a & b). Unlike collateral theory which construes the different schemas in a linear static form i.e. from parallel to secured collaterality, CAT construes the different schemas as dynamic since a given schema has the potential to change from one schema to another depending on the context in vogue. CAT is also useful in exploring the various stages in which learners are so as to determine appropriate remedial instruction deemed necessary.

From the foregoing, it is evident that while TAP is more applicable to a deductive-inductive classroom discourse while CAT deals with both logical and non-logical metaphysical discourses which go beyond the boundaries of science but which at the same time are part of human experience. What is evident from the theories treated so far is that they are all based on or draw inspiration from constructivist epistemology, especially social constructivism as espoused by Vygotsky (1978). But before going into this it is apposite to set the theory in proper historical context.

2.3 Social constructivism

The importance of prior knowledge, in contrast with the 'blank slate' notion of behaviourism, was acknowledged by Piaget, Bruner, Ausubel and Vygotsky. Thus this study has been influenced mostly by Vygotsky's social constructivism, which sees teachers as facilitators of the learning process and students as active constructors of knowledge. Piaget's theory of learning became the central principles of the constructivist revolution especially in the later part of the 20th century. According to Piaget knowledge is not determined strictly by the learner, or by the objects in the world that come to be known, but by the exchanges or interactions between them. In this sense he views learning as a natural process that is internally driven. A learner seeks for a balance between prior knowledge and new ideas. Two simultaneous processes of assimilation and accommodation are involved in searching for what Piaget terms equilibration.

Vygotsky (1978) proposed an important theory of the cultural and social dimensions of constructivism in terms of what probably takes place in the mind of the one constructing an idea. To him, learning of higher psychological processes and structures, such as science concepts occur on the social plane. In effect, such processes and structures are first encountered by learners as they listen to the talk of family, peers, community or read the writing of others. From his perspective, social context and language are fundamental to learning. Personal sense making of the conversations that surrounds them are critical, a link between the existing ideas and the new ones must be established. Learners must reconstruct the talk and activities of the social plane. In this regard he agrees with Piaget that the learner cannot be a passive recipient of knowledge.

Vygotsky is best known for his development of the notion of Zone of Proximal Development (ZPD), which supports a theory of assisted learning. Two levels of development are envisaged: What the learner can do on his/her own; and what the learner can do only with help from a more knowledgeable peer. This gap between the two levels is known as ZPD. The strength of the theory is seen as the important role it gives to the 'more capable peer', or the teacher, with whom meaning is developed through shared discourse. The mediator of this shared discourse is language, which Vygotsky regards as inseparable from thought. The most sensitive indicator of the success of a learner lies in her ability to narrow the gap between the levels. A more experienced partner is able to provide scaffolding of the subject matter to support the learner's evolving understanding. Learning is a social activity it is part of our interaction with others. Much of traditional education according to Dewey (1938) is directed towards isolating the learner from all social interaction.

The construction of new knowledge begins with our observations of events or objects through the concepts we already possess. The construction of knowledge can involve both naturally occurring events or objects and events or objects that humans construct. Culture is the vehicle through which children acquire concepts that have been constructed over centuries. Therefore they tend to hold dearly onto existing views and not relinquishing familiar ideas for new ones e.g. school science (Osborne and Freyberg, 1985). It is expected of teachers to cause learning in students, when of course learning must be caused by the learner (Novak & Gowin 1984).

2.3.1 Personal and social perspectives on science learning

Much of the earlier work carried out by 'constructivist researchers' especially those based on the Piagetian notion of learning focused on the individual learner, identifying patterns in the learner's existing alternative conceptions about particular phenomena, and also, investigating the conditions required for science learning to occur. Posner et al. (1982), in developing their 'Conceptual Change Model' of learning, identified the need for new knowledge to be 'intelligible', 'plausible' and potentially 'fruitful' for the learner if learning, or conceptual change, is to occur. Their focus was very much on changes in individual learners' conceptual frameworks, and hence this kind of perspective on learning is often called 'personal constructivism'. However, personal constructivist perspectives on learning say little about the social features of learning environments, such as interactions between groups of students, or teacher and students, and how these influence learning. More recently there has been a development in science education research towards acknowledging that learning a body of formal knowledge such as science – inevitably takes place in a social context (probably in a school), and that the social context is highly influential on learning.

2.3.2 Meaningful learning

Ausubel (1968) proposed a theory that contrasts rote learning with more meaningful learning that recognizes existing knowledge. As cited by (Freyberg, P and Osborne, R, 1985, piv): "the most important single factor influencing learning is what the learner already knows; ascertain this and teach him accordingly" (Ausubel, 1968). This statement is widely accepted and can be interpreted in a range of different ways i.e. find the alternative viewpoints possessed by the learner and provide material in such a way as to encourage the child to reconsider or modify these view points (Driver, 1980).

To learn meaningfully (as contrasted with rote learning), learners must choose to relate new knowledge to relevant concepts and propositions they already know. Rote learning, on the other hand, involves memorizing facts and concepts. His theory of meaningful learning presents learning as a process of assimilations where new knowledge is linked to existing cognitive structures. Meaningful learning thus depends on the prior existence of the concepts in the learner's cognitive structure. New ideas can also be obtained by the modification of existing knowledge. The quality and quantity of relevant concepts and propositional frameworks are primary factors in new learning (Novak, 1978). Hence it is imperative for teachers to find out what their pupils have already learnt as the result of their particular cultural and individual experiences (Osborne and Freyberg, 1985).

A somewhat different approach is suggested by Marton (1981). He argues for relational learning; i.e. the child's thinking is related to and determined by his or her complete environment. Children's experiences and values are determined by cultural, religious and social experiences. Bruner (1986) offers one way of characterizing relations, and that is through language. Bruner's idea is that language is a tool and the standards of its use perfect the mind and the hand. Without language, the mind and the hand alone cannot construct knowledge about the world. Language and its use are embedded in culture. Through classroom discourse, science language may be used for clarifying, elaborating, and transforming or giving new meaning to one's personal understandings of or description of the world. For young people learning science, this requires their participation, through talk and writing, in thinking through and making sense of the scientific events to which they are being introduced. It is perhaps in this regard that an argumentation-based classroom discourse becomes important. In a way, a classroom which provides opportunities for dialogues and arguments is more likely to evince learners' active participation in the learning process than otherwise.

2.4 Argumentation-based instruction

A definition of argument was provided by (Krummheuer, 1995: 231) as "the intentional explication of the reasoning of a solution during its development or after it." His definition includes dialogical argumentation pertaining to a situation where a number of contrasting lines are developed, especially where a number of people are involved. Dialogical interpretation of argument is involved when different perspectives are being examined and the purpose is to reach agreement on acceptable claims or courses of action. Such dialogical arguments or internal conversation can take place within an individual or within a social group (Ogunniyi, 2007a). In a technologically advanced era where socio-scientific issues, such as genetic engineering, reproductive technologies etc. are increasingly reported in the media (Osborne et al. 2004), there is an urgent need to improve the quality of young people's understanding of the nature of scientific argument. Our classrooms are riddled with lessons that emphasize "what" should be believed, rather than "why" it should be believed. Consequently the learners lack the necessary skills, confidence or resources to challenge the teacher's assertions. Argumentation is a useful method in the enhancement of scientific knowledge (Kitcher, 1988).

Toulmin (1958) developed a model of argument that has been drawn upon by educators and science educators in particular, to identify the components and complexities of students' arguments (e.g. Krummheuer 1995, Druker et al., 1996, Jimenez-Aleixandre et al. 1997). The model is referred to as Toulmin's Argument Pattern (TAP). He identified different types of statements which contribute to an argument, these are:

- Claims, assertions or conclusions whose merits are to be established.
- Grounds or data which are the facts that are appealed to in support of the claim
- Warrants which are the reasons justifying the connection between particular data and the knowledge claim
- Qualifiers: these specify the conditions under which the claim can be taken as true; they represent limitations on the claim.
- Backings are basic assumptions that provide justification for particular warrants.
- Rebuttals point to the circumstances under which the claim would not hold true.

Science is the production of socially constructed knowledge and entails the argumentative practices of the scientific community that is pivotal in the establishment of knowledge claims. Learning science involves becoming socialized into the languages and practices of the scientific community. Scientists engage in argumentation and it is through this process of argumentation within the scientific community that quality control in science is maintained (Kuhn, 1962). Science involves the construction of theories that provide explanations for how the world may be. In proposing provisional explanations for the underlying causes of events, theories are open to challenge and refutation (e.g. Popper, 1959). To become scientists, learners must make these forms of argument their own. Various studies have pointed to the value of talk to help students improve their understanding of scientific ideas. Our understanding of the significance of language in science, have been enhanced by these studies (Lemke, 1990).

2.5 Argumentation-based studies

The discipline of science is distinguished by its "central commitment to evidence as the basis of justified belief about material causes" and the rational means of resolving controversy (Siegel, 1989).

Dialogical argumentation uses TAP and can be facilitated in small-group discussions where the teacher's role is to act as an initiator of argumentative discussion, using a selection of arguing prompts. What is most gratifying about argumentation based instruction is the opportunity learners have to become good analytical thinkers. As Kuhn (1999) points out: "to achieve control of their own thinking is arguably the most important way in which people both individually and collectively take control of their own lives."

Newton et al. (1999:553) explored what sort of opportunities for discussion, argumentation and the social construction of knowledge existed in the classrooms of secondary science teachers. They found very little evidence of such practices. The science lessons were found to be teacher dominated. Two conclusions that the researchers arrived at were: "limitations in teachers' pedagogical repertoires and external pressures imposed upon science teachers in England by the National Curriculum and its assessment system". These teachers realized the need for argumentation-based instruction, but faced many constraints viz. time, curriculum demands and teacher training. We are similarly pressurized to complete a rather overloaded syllabus and to produce successful candidates. Matriculation results are the yardstick used to determine the effectiveness or otherwise of the education system. Unfortunately, most lessons are therefore teacher dominated and examination driven. It is in direct opposition to the idea of learners' participation through discourse (Driver et al. 1994). Argumentation lends itself towards small group work (Osborne, Erduran, Simon and Monk, 2001). In small groups learners are enabled to socially construct knowledge. Discussions of socio-scientific issues (such as water pollution, food safety, genetic engineering) could serve as stimuli whereby learners get the opportunity to engage in dialogical argumentation. Learners generally are initially reluctant to engage in argumentation. This is due to the teacher dominated form of instruction as well as the skills on the part of teachers to use such an instructional method. By creating opportunities for classroom discourse, learners argumentation skills can be enhanced (Driver, Newton, Osborne, 2000).

In scientific practices, scientists use argument to interrogate phenomena in their quest to advance science (Druker, Chen, and Kelly, 1996). Science teaching has however, paid little attention to argumentation as instructional method (Driver, Newton, Osborne, 2000). Yet many scholars have contended that argumentation is a necessary and alternative strategy to the current teacher dominated lecture approach, where science is presented as the social construction of scientific knowledge. Unfortunately, they found (Driver, Newton, Osborne, 2000, p309) that: "few teachers have the necessary skills to effectively organize group and class discussions…consequently such activities rarely, if ever, take place". Teachers need to be trained in the art of argumentation was one of their recommendations.

In a research project (Osborne et al., 2001) developed models of instructional activities and found that introducing argument in a science classroom is not easy. They proposed various strategies for supporting argumentation. Teachers roles in argument would be: to organize small groups; act as initiator of argumentative discussions; to provide writing frames to assist the write-up process; facilitate role plays and allow group presentations. Argumentation-based instruction provides learners with an opportunity to practise and develop analytical skills. TAP can be used to determine the quality of argumentation, as the quality of argumentation is defined in terms of the presence and nature of rebuttals used by learners (Erduran, Simon, Osborne, 2004). The aforementioned researchers concur with others (Kelly and Takao, 2002) that it is difficult to identify the components of TAP i.e. to differentiate between data and backings or warrants and backings, but easier to distinguish claims or rebuttals. They developed an analytical framework to assess the quality of argumentation which range from: level 1 to level 5. The higher order argumentation, level 5, consists of more than one rebuttal. I found that learners initially made claims without evidence, after I explained that it signifies a weak argument (Simon, Erduran and Osborne, 2006) they changed it in the next lessons. Supplying arguing prompts, such as "why?" or "how do you know" (Simon, Erduran and Osborne, 2006, p250), proved to be very valuable when learners started with the notion of claim and evidence.
Many studies have shown the importance of argumentation and dialogue as useful tools for enhancing teachers' and learners' conceptual understanding as well as increasing their awareness of the tentative and material-discursive nature of scientific practices (Barad, 2000).

2.6 Language

The importance of language to the learning of science has long been recognized, but recent theoretical work on learning in science has fore grounded language even more than it has been in the past (e.g. Scott 1998). Unfortunately, decisions concerning the use of language in the classroom are frequently not based on findings related to best practice in education. Rollnick (1998), make the point that such decisions are often made on political rather than educational grounds. Further, the implications of these decisions may reach far beyond the classroom. It would not be too far-fetched to say that the 1976 riots in Soweto, sparked off by a dispute about medium of instruction, proved to be a turning point in the battle against apartheid in South Africa. She stressed further that the second language (L2) learners of science are those who often are citizens of a multilingual country where the language of official communication and the economy is a former colonial language appropriated for social use and who are 'officially' taught at school through the medium of that language.

2.6.1 Views about first language instruction in science

In South Africa Heugh (1999) shows that the pass rate of school leavers has actually dropped since 1976 when there was a minor change of language policy, largely as a result of political uprisings. Before 1976, black children in South Africa were taught in their home language throughout primary school. In secondary school they switched to English and Afrikaans. The issue sparking off the riots was in fact the so-called 50:50 policy in the secondary schools, where pupils were compelled to learn half their subjects through the medium of Afrikaans and half though the medium of English. This unpopular policy was dropped after 1976, but so was the policy of 'home language only' in primary school, which Heugh maintains was beneficial. The policy which replaced this, similar to several Anglophone countries in Africa and Asia, is one of home language instruction for four years and a switch to English in the fifth year. Bunyi (1999) argues strongly for home language instruction. She produces data from Kenya to show how the use of English leads to inequalities in education. She maintains that when science is taught through the medium of English, learners are not able to apply what they have learnt in science to everyday life. She argues that all languages have the capacity to develop and meet all communication needs of the users. In another Kenyan study at the primary level, Cleghorn

(1992) found that important ideas were conveyed more easily when the teacher did not adhere to the policy of English-only instruction.

2.7 Summary

Learners come to school with prior knowledge that they have gained from interactions with others, especially from their families and communities. Through observations, hands-on experience and folklore they possess a rich indigenous knowledge of the environment. In the current science classrooms learners' indigenous knowledge is largely ignored as many teachers seem oblivious of its importance or even existence. Some learners experience difficulty in crossing cognitive cultural borders, for some it is impossible to make a transition. It is primarily for these learners that an alternative instructional method such as ABI might prove useful in helping them to make meaningful border crossing between their experiences at home and at school. ABI is a teaching method that supports learners' participation and values (Ogunniyi, 2007a). In a typical lesson learner participation is generally limited to taking of notes, an occasional interest in learning material and the acquisition of enough knowledge to pass examinations. I have found that when they are however stimulated by thought provoking learning materials e.g. by introducing them to contentious issues they suddenly come alive so to speak. Also, when given the opportunity to engage in dialogical argumentation they seem to show great enthusiasm and interest and become very active in class. In the small groups ideas are exchanged and challenged even the learners who seldom contribute do not hesitate to state their positions. As Ogunniyi has argued, IKS is a 'redemptive, holistic, and transcendental view of human experiences with the cosmos-a subject which often are of greater intellectual interest to learners from indigenous communities than the remote and abstract scientific concepts to which they are exposed in the science classroom. Unlike science, "whose ethos is reductionism, IKS celebrates plurality, diversity, and the holism of human experiences" (Ogunniyi, 2007a:965) but these are not strictly speaking part of the science they learn at school. Chapter 3 provides details of how the study was conducted to motivate the learners not only to consider the standard account of water pollution as presented in their science textbooks but also with environmental knowledge which they could relate to in their immediate environment.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

The objective of this chapter is to discuss the methods and procedures used in carrying out the study. In chapter one I presented a historical account of the school where I teach and the type of learners who attend the school. There, I explained that most of my learners are very de-motivated. As underachieving learners, it is not difficult to know why they hold a negative view about science or education in general. Therefore, to motivate this type of learners, one needs to be creative. One way to do this is to engage them on topics with direct practical application to their lives outside the school environment. The integration of everyday, outside–school phenomena in science teaching is not only necessary but also urgent (Soudani et al., 2000). Although water comprises over 70% of the earth's surface only 3% is fit for human consumption, therefore the threat of water pollution to a very scarce life source can be viewed as a contentious issue.

3.2 SAMPLE

The subjects of this study consisted of 59 grade 10 learners, 38 girls and 21 boys from the same school. To select the subjects, a convenient sampling approach was adopted. With the current strict research policy, and after initial abortive attempts to secure another comparable group, it became necessary and convenient for me to use my own learners than the learners of other science teachers. With the exception of my learners and their parents or guardians, and the school administration, I did not have to ask permission from anyone to conduct my research. To avoid the effect of history of the two identical groups, experimental (E) and the control or rather the comparison groups (C) were used. Although in the extant literature the two terms are used interchangeably my preference is to use the latter because of the subtle differences between the two terms. However, for ease of reference and to avoid confusion, I will stick to the commonly used term "control" instead of "comparison" group.

In an ideal experimental setting the experimental group receives treatment while the control group is deprived of such a treatment. However, for ethical reasons, I could not concentrate on the learners in one group while leaving learners in the other group to a watered down chalk-and-talk approach or leave them to their own devices. In other words I had to invest as much time and energy on both groups, though in reality only the E group would receive the treatment namely, an argumentation-based instruction while the C group would receive an alternative treatment, namely the lecture-demonstration instructional approach which I normally used in my teaching before I was introduced to an argumentation pedagogy. According to Wollpert (1981):

> In experimental research, the issue of the critical comparison is of paramount importance. Our judgments as to the effect of an experiment are, as it is the case with all other judgments, relative. But relative to what? That is the question which focuses on the issue of critical comparison. Most judgments of the effect of treatments used in traditional experimental research are made by using as a critical comparison the measurements obtained from an *experimental group* which received a treatment compared to the measurements obtained from another similar group which did not receive a treatment. This other group used for comparison purposes is referred to as the control group. (p. 89)

The next challenge was that the two groups were in the same school. How does one navigate his way without falling foul of bias? The question of using learners in the same school normally raises the question of contamination of data. In chapter one as well as in the introduction of this chapter, I have explained the type of learners I am working with. Outside the classroom environment very little discussion around relevant school material happens. Due to the fact that the study was conducted during teaching time, the normal school timetable had to be followed and classes had to be intact. Despite this limitation however, the consolation for me was that the two groups had similar socio-economic backgrounds and had passed through similar historical events and disadvantaged school settings. Before the study was conducted, in 2010 at my school, a pilot study was done with a different cohort of learners in 2008. The purpose of the pilot study was to familiarize myself with using argumentation-based instruction as well as to develop the instruments to collect data.

3.3 RESEARCH PROCEDURE

The study applies both qualitative and quantitative research methods. The reason for this was to strike a balance between the two since each has something to contribute to the study. The use of both research methods has afforded me the opportunity to collect a more holistic data set that would not have been the case if I had used only one method. Qualitative data were derived from the learners' written responses to the Water Pollution Achievement Test (WPAT) as well as the Focus Group interview. The quantitative data were derived from the learners' performance scores in the Water Pollution Achievement Test (WPAT). It has also provided me a greater insight into the issues at stake. The initial pool of this study consisted of 59 grade 10 learners. However, because some learners did not write the pre- or post-test, the total number was reduced to 42. The study was conducted during the second term over a period of three weeks, nine periods of 50 minutes each.

The learners were given notes on water pollution to prepare for the following day's argumentation-based lesson. They were divided into six small groups. They had to discuss the different sections pertaining to water pollution. Each group had to write their own arguments to the focus points and had to report to the entire class. All the learners further discussed the answers given by the groups. At the end of the lesson I felt we could have discussed the topic further as the learners seemed to show great interest in the topic. However, timetable constraints allowed for only three weeks treatment though four could have been more appropriate.

This study recognizes the central role of the learners in defining the completion of any lesson. According to Ramorogo (1998) a hermeneutic perspective of teaching and learning should take into account the perspectives of the learners about teaching and learning. Thus, at the end of the three weeks of the study, a few learners were exposed to a focus group interview to reflect their perceptions of the study, particularly with respect to the argumentation-based instruction on a controversial topic, water pollution.

3.4 PHASES OF THE STUDY

The study consisted of three phases, i.e. preparation phase, pilot phase as well as the main study. The interview schedule and the Water Pollution Achievement test (WPAT) were developed during the preparatory phase. The pilot study was undertaken with the purpose of getting familiar with Argumentation-based Instruction (ABI) as a teaching tool prior to implementing it in the main study. Data in the main study was collected through quantitative and qualitative methods. Once data had been collected, it was analysed and conclusions drawn. Data for the quantitative aspect of the study was collected through the implementation of the WPAT administered to the learners. Data for the qualitative aspects was collected through a focus group interview at the end of the study. The collected data set was then analysed and findings communicated with implications thereof suggested.

3.5 THE RESEARCH DESIGN

The quantitative research design used in the study was a quasi-experimental pre-test post-test control group design. The design consists of one experimental group (E) and one control group (C) as shown below:

O_1 x O_2 Experimental group

O_3 O_4 Control group

O_1 and O_3 are the pre-tests and O_2, O_4 are the post-tests while x stands for the treatment (argumentation-based instruction). The groups were not derived from a randomization process but rather were intact classes. The lines indicate that intact rather than randomized groups were used (Ogunniyi, 1992:91). The E group received treatment (X) in the form of argumentation-based instruction (ABI) whilst C received an alternative treatment. According to Ogunniyi (1992) this design is tight enough to eliminate possible sources of extraneous variables, e.g. history, mortality of subjects, statistical regression, etc., which might affect the validity of the instrument and or the quality of the data obtained.

The two groups were exposed to equal teaching hours, consisting of nine periods of 50 minutes. In consonance with Learning Outcome 3 of the new South African curriculum (previously called Curriculum 2005 (C2005) for the Natural Sciences, effort was made to ensure that the learners were “able to demonstrate an understanding of the relationship between science and society, and the impact of science on society" (Department of Education 2002:10). Learning Outcome 3 seems to be the most amenable to discussing socially related issues and problems like water pollution. According to the same document, "Learning Outcome 3 calls for the student to become a scientific problem solver in the context of South African Society" (Department of Education; 2002:10).

The learners of group E were introduced to ABI while their counterparts in C were only exposed to expository lecture mixed with teacher demonstration. This method enabled me to determine the effectiveness of the intervention in the development of the learners' conceptual understanding of water pollution.

The qualitative component of the study involved a focus group interview and excerpts from Water Pollution Achievement Test (WPAT). My use of multiple methods, such as interviews, observations, questionnaires and video/audio recordings was to provide a more holistic and comprehensive data set than would have otherwise been the case if I had relied on only one data source. This approach is referred to in the literature as triangulation (Denzin, 1978a). All the comments made by the learners during the study (audio recordings) were also used as part of the qualitative data which provided additional insight to classroom transactions throughout the study. The latter was used to corroborate the quantitative data. A video footage was taken in the E group in order to get a clearer view of how effective or otherwise the intervention strategy was carried out. The video footage also afforded me a better reflective opportunity.

As indicated earlier, one there might be concerns about my learners and coming from the same school would communicate with each other and share this new method hence the validity and reliability of the study will be greatly compromised. However, with the situation in my school, this problem was not evident throughout the study period as I saw nothing to such contamination either in class or their responses to the various instruments. The culture of learning was virtually absent amongst these learners.

3.6 Class demographics

The science classes on average have 40 learners. The ages of the learners range from 15-18. Although 59 grade learners took part in the study, the analysis focused on the pre- and post-test responses of only 42 learners. The reason for limiting the number is that some learners wrote either the pre- or post-test only. This therefore, rendered their tests unusable for comparison purposes and hence were discarded. In other words, only those that wrote the pre- and post-test were deemed useful. The 42 learners were selected on the basis of stratified sampling to reflect the male and female ratio.

Table 3.1: Class distribution with valid test results (gender).

Groups	Male	Female	Total
E	10	11	21
C	12	9	21
Total	22	20	42

Table 3.2: Class distribution with valid test results (age).

Age range	N
15-16	20
17-18	22
Total	42

The majority of the learners came mainly from the surrounding areas including the informal settlement. Most of the learners walk or travel by bus to school. The learners come from economically disadvantaged communities.

3.7 INSTRUMENTATION

The use of the same test as pre- and post-tests as well as one person doing the research helped to eliminate the problem of instrumentation threat. Instrumentation threat occurs when a different test from pre-test is used as a post-test and the levels of difficulty for the two tests are not the same (Trochim and Land, 1982).

Due to the different approaches used in conducting this study, a number of instruments were used to collect data. They are:

1. The Water Pollution Achievement Test WPAT, which was the pre- and post-test (see Appendix B) instrument for determining the learners' conceptions of water pollution. The data collected through the WPAT were analysed in terms of quantitative and qualitative descriptions.
2. The focus group interview included:
   (i) A focus group interview carried out to explore the learners' perceptions of ABI and its effect on their understanding of water pollution.

3.7.1 Validation and Reliability

All instruments were tested for validity and reliability to ensure that the study and the instruments measure what they purported to measure (Ogunniyi, 1992) and further that they would provide consistent results in two or more similar situations. To attain face, content and construct validity, all the instruments were given to five experienced science teachers, four student colleagues and three lecturers for scrutiny purposes. They were specifically required to assess: (i) the appropriateness of the level of language used to the target learners; (ii) the clarity of the questions; (iii) whether or not there were any overlapping questions and (iv) whether the content was at the level of the learners and measured what would be taught or not. Each question was rated by the panel from 1 – 5, i.e. 1 for a poor; 2, fair; 3, reasonable; 4, very good and 5, for an excellent item. To improve the validity of each instrument the rating by the panel on each item were randomly grouped into two groups the average score of one group was correlated with the other using the Spearman Rank Difference formula (see Ogunniyi, 1992). The resulting correlation coefficients for the WPAT stood at 0.81. During the pilot study the teaching – learning tools and instruments developed for the study were administered. Shortcomings of the research design were noted and amended. For example, after the pilot study some of the items of the WPAT were replaced to make it relevant to the study.

3.7.2 Water Pollution Achievement Test (WPAT)

The (WPAT) was developed to measure the cognitive achievement of the learners in the experimental and the control groups. The (WPAT) consisted of content – based questions derived from the syllabus. These questions were designed to elicit information about the learners' water pollution knowledge and reasoning.

A summary of the WPAT is shown in Table 3.3 below, but the actual test is available in Appendix B.

Table 3.3: Summary of Water Pollution Achievement Test (WPAT)

Question	Summary
1.1	Consider the picture and list the possible causes of water pollution in river A.
1.2	Why is fishing not allowed?
1.3.1	How can a river near you be kept clean as illustrated by river B?
1.3.2	Identify the differences between rivers A and B.
1.4	There are two different ways in which water pollution occurs, namely point source and non-point source pollution. Explain the difference between the two (give examples).
1.6	What are the implications of dense plant life to aquatic life? Explain your answer.
1.7	In addition to innocent organisms dying off, our drinking water has become greatly affected as is our ability to use water for recreational purposes (see river A). In order to combat water pollution, we must understand the problems and become part of the solution. Suggest a few possible solutions to water pollution.
1.8	Do you think household chemicals cause water pollution? Yes/no. Then provide reason(s) to support your answer.
1.9	Who should be responsible for the eradication/control of water pollution?
3.1	What do you think is/are the cause(s) of them feeling sick?
3.2	How will you purify the water in question (3.1) Name four steps in the process?
3.3	What diseases can you get if you drink the untreated water?
3.4	Many people assume that "clean" river water is safe. Do you agree? Give reason(s) for your answer.
4.1	What are the possible causes of the pathogens?
4.2	How hazardous it is.
4.3	How can the pathogens be minimized?

Classification of questions

The questions on WPAT were divided into three process skills, i.e. Recall, Applying knowledge and Communicating. Table 3.4 shows where each category of question fits:

Table 3.4: Process skills implied by the items in WPAT

Question	Summary	R	A	C
1.1	Consider the picture and list the possible causes of water pollution in river A.	x		
1.2	Why is fishing not allowed?		x	
1.3.1	How can a river near you be kept clean as illustrated by river B?	x		
1.3.2	Identify the differences between rivers A and B.		x	
1.4	There are two different ways in which water pollution occurs, namely point source and non-point source pollution. Explain the difference between the two (give examples).			x
1.6	What are the implications of dense plant life to aquatic life? Explain your answer.		x	
1.7	In addition to "innocent" organisms dying off, our drinking water has become greatly affected as is our ability to use water for recreational purposes (see river A). In order to combat water pollution, we must understand the problems and become part of the solution. Suggest a few possible solutions to water pollution.	x		
1.8	Do you think household chemicals cause water pollution? Yes/no. Then provide reason(s) to support your answer.	x		
1.9	Who should be responsible for the eradication/control of water pollution?	x		
3.1	What do you think is/are the cause(s) of them feeling sick?		x	
3.2	How will you purify the water in question (3.1) Name four steps in the process?		x	
3.3	What diseases can you get if you drink the untreated water?		x	
3.4	Many people assume that "clean" river water is safe. Do you agree? Give reason(s) for your answer.		x	
4.1	What are the possible causes of the pathogens?			x
4.2	How hazardous the pathogens are?			x
4.3	How can the pathogens be minimized?			x

R = recall, A = applying knowledge, C = communicating knowledge

There are 5 recall questions making 39.5 %, the applying knowledge questions form 37.5 % and communicating the 23 % of the test. As stated earlier, the (WPAT) was administered by me as a pre-test (see Appendix B). This was meant to ensure that the learners actually understood the questions. The learners were told that the test was not for continuous assessment (CASS) purposes. This was to ensure that the learners were relaxed while answering the test. This also eliminated the learners' anxiety, which sometimes causes the learners to fail a test even though they know the content.

The learners had to work in groups. When the learners worked in groups they were offered the opportunity to verbally interact, thus sharing their understandings and the knowledge they had acquired. Group work can improve the quality of learners' responses to problems that require their ability to think. The group setting also affords one an opportunity to learn to contribute and receive ideas, defend his/her ideas and accept and go along with other people's ideas (Ramorogo, 1998). According to Reid and Yang (2002) letting the learners work in groups gives them the opportunity for their previous knowledge and working memory space to be combined. Reid & Yang (2002) further assert that the number of participants in a group should be determined. They cited Grant and Heller & Hollabaugh as suggesting three learners per group as reasonable for optimal interaction. In a group of two members, a student might feel embarrassed with an uncooperative partner. At the same time, if the group is too big, some learners might not participate. However, having worked with three learners per group during the pilot study, for the main study, learners were grouped into fives with specific roles to play.

3.7.3 Interviews

Interviewing has become a way of life in society (Atkinson & Silverman, 1997). Research interviews assume that the individual's perspective is an important part of the fabric of society and of our joint knowledge of social processes and of the human condition. Historically individuals (other than those in leadership i.e. heads of tribes or churches, dukedoms, kingdoms etc.) views were not considered (Gubrium & Holstein 2002:7). In an interview-oriented and information-seeking society (Atkinson & Silverman, 1997) people are subjected to one form of interview or the other either as individuals or group. It is used as a means of engaging with people seeking employment, for therapy and counseling, and also as a strategy to ascertain learners' classroom experiences. The main aim of interview data is to "hear", more what learners (participants) thoughts are, whether they have conceptualized the intended content and to value their experiences or not. In our interview society we have come to rely on the personal views of what goes on in people's lives. We are warned by researches that we should not just "listen" to what people say and then in a "crude" empiricist (Silverman 1993:78) way, report it. It is not only what, but also how they say it that needs to be reflected. The problem with interviews is that they are unnatural interactions (Measor, 1985). This weakness however, can be overcome by building a relationship of trust with interviewees. To further probe the learners' perceptions of water pollution a focus group interview was conducted.

The interview also went through a vigorous validation process. It was given to the same panel for face, content and construct validation. Using the Spearman-Brown correlation reliability formula, the reliability coefficient for the focus questions of the interview on learners' perception and understanding of water pollution was 0.78.

3.7.3.1 Interview on Learners' Perceptions of Water pollution

The interview was used to explore the learners' perceptions of the use of argumentation-based instruction and how they thought it affected their conceptual understanding of water pollution. An in-depth non-directive interview was selected for the study as it gave respondents the opportunity to speak freely and fully. The learners' argument had to focus and address the following questions:

Learner interview schedule:

1. Have you received instruction on water pollution in previous years and in what grade(s)?
2. Whose responsibility is it to keep water resources clean?
3. Should people/companies/farmers i.e. the perpetrators be fined, for polluting the water resources?
4. Do you think enough emphasis is placed on keeping water resources clean?
5. Were the group discussions/ argumentation beneficial?
6. Did you get an opportunity to raise your viewpoints? Were the discussions dominated by anyone?

7. What aspect(s) of the argumentation-based instruction did you enjoy or disliked.
8. Do you think argumentation-based instruction should be used in a science classroom?

Learners were encouraged to speak freely and even use their own mother tongue so that they could express themselves fully. This was a group interview, involving six learners. I concur with Ramorogo (1998) when he asserts that using group interviews is:

> … necessary because of not only the obvious cost of time and materials spent interviewing, but also because interviewing learners in a group helps recreate the ideas about classroom experiences better than when individuals are interviewed (p.135).

Ramorogo (1998) further asserts that group interview reduces interview stress on the participants.

3.8 DATA ANALYSIS

Due to the eclectic approach used in both the teaching of the lessons and the collection of the data, the data were analysed using both qualitative and quantitative descriptions (Ramorogo, 1998).

For quantitative data analysis, descriptive statistics used included mean, standard deviation and percentages. The inferential statistic used was the t-test. According to Patton (1989) quantitative measures are succinct parsimonious and easily aggregated for analysis. Also, they are systematic, standardized and easily presented in a short space. It is for the same reason that quantitative analysis was used to explore certain aspects of the data collected.

The qualitative data were obtained from listening to the learners' responses at the interview (audio recording) and collating their responses on the WPAT (verbatim) written comments.

The responses obtained from these two sources were analysed in terms of qualitative descriptions in form of excerpts derived from the learners' statements on the issues relating to water pollution and the effectiveness or otherwise of argumentation-based instruction.

3.9 LIMITATIONS OF THE STUDY

This study was limited to one school which was more convenient for the researcher as he had to work with his own learners and thus avoid the current difficulties due to the new education policy of obtaining permission to conduct the study. However, the permission of the learners and the school administration were obtained before commencing the study. Under normal circumstances this could pose a problem of contamination of treatment from the others, but due to the type of learners I teach the chances of contamination of data were rare. It was for the same reason that the group that received the alternative treatment was not considered strictly as the control group but a comparison group (Wolpert, 1981).

For the pilot study having to analyze the responses of only 18 subjects make it difficult to assume that a similar experience would be encountered the larger number of subjects envisaged for the main study. Also, conducting a study with grade 10 learners during the second term imposed time constraints on me, and it left me with only three weeks to collect data. These settings led to the short circuiting other tools and minimize questions and statements that I would have liked to use. This certainly impacted on the amount of data that I was able to collect. This has also led to the exclusion of some of the instruments, as they required more time. Some learners' attendance was generally poor. This implied that some of the learners although they wrote all the tests and answered the questionnaires, might have been absent during a big part of the lesson. Despite all these challenges I did my best to acquire the necessary data to ensure the success of the study.

3.10 ETHICAL ISSUES

Researchers in the social science arena, like those in science also have an obligation to maintain ethical standards when conducting research. Social scientists have been moving towards some consensus on basic ethical guidelines for conducting research involving human subjects (Smith, 1975). The quasi-experimental design used in the study implies subjecting a certain group to a particular teaching strategy while another group is exposed to another strategy or denied one activity or the other. To achieve equity and fair play all the learners were exposed to the same lesson material. The only difference between the experimental (E) and the control (i.e. comparison) group (C) is that while the former was exposed to argumentation-based instruction the latter was taught the expository instructional approach. Besides, permission was sought from the Headmaster, the Head of Science Department and learners themselves. All the learners without exception willingly participated in the study, particularly as it related to their class work and their experiences in the communities where they came from. Also, for anonymity purposes the name of the school where the study was conducted and the learners' names have not been disclosed in this report.

3.11 Summary

This chapter looked at the research design and methodology applied in carrying out the study. The main study was conducted after a pilot study was undertaken to better equip me for the main study. The main study was a quasi-experimental design. The groups used were the E and C groups. The WPAT provided data for the quantitative aspect of the study while the interview and excerpts (from WPAT) provided data for the qualitative component of the study. The findings are discussed in chapter four while the conclusions reached and their implications are presented in chapter five.

CHAPTER 4:

Results and Discussions

4.1 Introduction

In line with Learning Outcome 3 (LO3) of the Revised National Curriculum for the Natural Sciences to make science relevant to the students' life worlds (see Department of Education, 2002), the purpose of this study was to determine the effectiveness or otherwise of argumentation-based instruction (ABI) on grade 10 learners' understanding of water pollution at a river site.

Using water pollution which form part of the water cycle theme in the grade 10 syllabus, it was assumed that a controversial topic such as this would be an excellent choice for argumentation-based instruction. Learners are supposed to be acutely aware of the environmental impact of water pollution in the light of global warming. The purpose of this chapter is to present and discuss the results that emanated from the study in terms of the research questions.

As water pollution were introduced to all the learners, only argumentation-based instruction served as the treatment between the experimental (E) and the true control group (C).

In pursuance of the purpose of the study, three instruments, described in chapter three, were administered to collect data. The collected data were then analysed quantitatively and qualitatively. The instruments used to gather the data are: Water Pollution Achievement Test (WPAT); one questionnaire and a focus group interview. Although 65 grade ten learners were involved in answering the pre-test, only the results of 21 learners in each class were analysed and discussed in this chapter. Many learners who wrote the pre-test did not complete the post-test and were consequently omitted from the analysis. The analysis reported in this chapter is based on data collected from 21 learners per group who completed both the pre- and post-tests. The data collected at the pre- and post-test stages were grouped according to their gender and age. The statistical analysis was performed in order to determine the effect of the treatment, argumentation-based instruction on the learners understanding of water pollution. The qualitative data gathered from the focus group interview and questionnaire were analyzed and presented in form of excerpts to corroborate the quantitative data. The results obtained from this analytic procedure are presented in the following sections.

4.2 Pre-test results on Water pollution (WPAT) achievement test

As mentioned in chapter three, the WPAT consisting of 16 items, were grouped into three main themes viz. process skills i.e. Recall, Applying knowledge and Communicating. The Experimental Group (E) and Control Group (C) responded to the WPAT at the pre-and post-test stage. The null hypothesis for testing was that there would be no significant difference between the means of the two groups with respect to gender. As can be seen in Table 4.1 the number of males and females are closely correlated to reflect the population of each group with respect to gender.

Table 4.1: Frequency of learners involved in each of the groups in the study.

Groups	Male	Female	Total
E	10	11	21
C	12	9	21
Total	22	20	42

4.2.1 Research Q 1: What conceptions of water pollution do grade 10 learners hold?

Grade 10 learners' conceptions of water pollution.

4.2.1.1 Pre-test Results

The mean is a useful statistic for measuring the concept of average in a distribution. It measures the values of each score in a distribution and forms an important component in interpreting central tendency. However, it is very sensitive and can be easily affected by extreme scores in a distribution. Hence, for ease of reference and to avoid interpretation errors, it is better to convert mean scores into mean percentages (Ogunniyi, 1984, 1992). Table 4.2 below shows the learners' performance on the WPAT with regard to gender at the pre-test stage.

Table 4.2: Pre-test Scores obtained by learners on the WPAT.

Gender	Group	N	Mean	Mean %	SD
	E	21	12.76	21.27	2.18
	C	21	13.05	21.75	4.05
	t_{obs} (0.29) < t_{crit} (1.684)				
Female	E	11	13.45	22.42	2.2
Male	E	10	12.0	20.0	2.0
	t_{obs} (1.57) < t_{crit} (1.729)				
Female	C	9	13.22	22.04	5.34
Male	C	12	12.92	21.53	2.98
	t_{obs} (0.164) < t_{crit} (1.729)				

P = 0.05

Judging by the mean percentages of 21.27% and 21.75% for E and C respectively, it is obvious that they are low. However, the relatively low standard deviations of 2.18 and 4.05 for E and C respectively, are indicative that the two groups were comparable. The t-test for the pre-test scores for both groups stood at 0.29. This value is less than the critical value required to reject the null hypothesis, namely, 1.684. Since the obtained value is less than the critical value, we cannot reject the null hypothesis suggesting no significant difference between the pre-tests of the E and C groups. This further reinforces the idea of comparability of the groups at the pre-test stage. Both groups performed similarly in the WPAT at the pre-test stage. A difference at post-test stage, if any, could then be attributed to the treatment.

Based on the t-test scores for the pre-test, there was no significant difference between the boys and the girls. The mean percentages for C of both genders were very close, i.e. 22.04% and 21.53% for the girls and boys respectively, thus indicating the comparability of the two gender groups. The t-test score of 0.164 is less than the critical value of 1.729 needed to reject the null hypothesis at p = 0.05. Thus, the differences between the boys and girls in the control group, is not statistically significant at the pre-test stage. Also, the mean percentages for E were 22.42% and 20.0% for the females and males respectively. This suggests that the females had a slightly better understanding of the topic than the males. The t-test score of 1.57 is less than the critical value of 1.729 needed to reject the null hypothesis at p = 0.05. Thus, the differences between the females and males in both groups are not statistically significant at the pre-test stage.

Since there was no intervention before the pre-test the performance of learners in the WPAT is indicative of prior conceptions of water pollution. Question 3 deals with the collection of water from a local river in a rural community. The traditional methods used to purify water for household purposes were interrogated. Some learners could relate to the scenario depicted on the WPAT while others could not, depending on whether or not they were familiar with a rural setting. Those from urban areas knew only about tap water that is clean enough for usage. They were unaware of the purification processes involved in producing clean tap water. Two control group learners C11 and C5 answered as follows:

Question 3.2: How will you purify polluted river water?
C11: By keeping the river clean, removing debris.
C5: I will first boil the water, let it cool down and then store it in the fridge.

Learner C11 is satisfied with a river that is free of visible pollutants, such as plastic bottles. This exemplified many learners' prior knowledge about water pollution at the pre-test stage. Learner C5 clearly demonstrated some knowledge about the purification process. Although this answer does contain some elements of TAP i.e. linking the claim implied in the question with some warrant namely, boiling water, letting cool down (perhaps to let it settle down) before storing it in the fridge. Of course cooling water down does not necessarily purify it. Otherwise, the reason for boiling the water was not expressed or it was perhaps unknown. For example, question 3.4 was answered as follows:

Question 3.4: Many people assume that "clean" river water is safe. Do you agree? Give reason(s) for your answer.
Learner E3: Yes, then you can see whether there are broken glass in the water.

Again visible pollutants were noted at this stage it seemed as if this learner was oblivious of the existence of micro-organisms. I was particularly interested at the post-test stage to see if E3 would advance a more valid reason than has been the case.

Question 4 required learners to explain the relationship between pathogens and polluted river water. A few learners probably understood possible relationship between pathogens and diseases. As examples, learner E1 said that, "Human and animal waste, are the causes". Another learner, C11 said that, "Dumping your washing water in the river" caused pathogens to spread." Again some warrants or grounds were posited to explain the link between diseases and pathogens.

Questions 3 and 4 tested learners' knowledge of traditional practices and scientific knowledge respectively. The learners' responses ranged between simple phrases to short statements about the link between water pollution and pathogens. In terms of TAP, most of the responses were at the lowest level of non-oppositional claims sometimes with some elements of warrants or grounds and at other times with no evidence of such support. I must admit that apart from the language related issues, the examination-oriented items on the WPAT probably did not provide sufficient intellectual space for the learners to externalize their worldviews. In future studies effort would be made to see to it that the scenarios do provide learners with more opportunity to reflect their cultural ideas about water pollution than has been the case in this study. It is not clear at this exploratory stage how beneficial was the TAP-based instruction to the learners or how much of their responses were derived from school science or IKS-based cultural practice.

4.2.2 Research Q 2: What process skills do grade 10 learners use to perform cognitive tasks on water pollution?

Grade 10 learners' Performance based on Process skills displayed.

The learners' achievement in terms of percentage performance for the selected process skills (recall, applying knowledge and communicating) are depicted in Table 4.3.

An examination of the table reveals that the learners' pre-test scores per item for the experimental group (E) and the control group (C) range between 3 % to 40 % and 5 % to 48 % respectively. The average performance on the instrument was 23 %. Item 3.4, i.e. many learners assume that "clean" river water is safe attracted the lowest percentages of the correct responses, i.e. about 3 % for E and 5 % for C. This indicates learners' poor conceptions of water pollution and they are not aware of the dangers lurking in "clean" river water. Item 4.3, "how can the pathogens be minimized?", also attracted a very low percentage of correct responses, i.e. about 5 % for E and 10 % for C. This shows learners' poor conceptions of what water pollution entails. They mostly describe water pollution in terms of the unsightly appearance of refuse (plastic bags, bottles, papers etc) in rivers. Item 3.3, "what diseases can you get if you drink the untreated water", attracted the highest percentage of correct responses of 40 % for E and 48% for C. This suggests that the majority of the learners' have an idea of the diseases caused by polluted water. It could be due to prior knowledge or media reports about the high prevalence of cholera in the Kwa-Zulu Natal province. In Table 4.3.1 results are presented in descending order (also note: Water pollution (water poll).

Table 4.3.1 Percentages of Correct Responses to selected Items of the WPAT at the Pre-test stage.

Items	Summary of items	E(%)	Items	Summary of items	C(%)
Recall					
1.1	Possible causes of water poll	36	1.3	How can a river be kept clean	37
1.3	How can a river be kept clean	33	1.1	Possible causes of water poll	31
1.9	Who's responsible for the control of water pollution	27	1.9	Who's responsible for the control of water pollution	24
1.7	Suggest solutions to water poll	24	1.7	Suggest solutions to water poll	22
1.8	Do household chemicals cause water pollution	18	1.8	Do household chemicals cause water pollution	14
Total	Average %	28	Total	Average %	26

Items	Summary of items	E(%)	Items	Summary of items	C(%)
Applying knowledge					
3.3	What diseases can you get if you drink the untreated water?	40	3.3	What diseases can you get if you drink the untreated water?	48
1.2	Why is fishing not allowed?	25	1.2	Why is fishing not allowed?	22
3.1	What do you think are the causes of them feeling sick?	21	3.1	What do you think are the causes of them feeling sick?	21
3.2	How will you purify the water?	14	3.2	How will you purify the water?	18
3.4	Is clean river water safe?	3	3.4	Is clean river water safe?	5
Total	Average %	21	Total	Average %	23

Items	Summary of items	E(%)	Items	Summary of items	C(%)
Communicating					
4.2	How hazardous is it?	25	4.2	How hazardous is it?	33
4.1	What are the possible causes of the pathogens (bacteria etc.)	23	4.1	What are the possible causes of the pathogens (bacteria etc.)	15
4.3	How can the pathogens be minimized?	5	4.3	How can the pathogens be minimized?	10
Total	Average %	18	Total	Average %	19

An examination of Table 4.3 shows that the overall learners' performance for the selected process skills, for E and C respectively at the pre-test stage, were as follows:

- Recall E = 28 % and C = 26 %
- Applying knowledge E = 21 % and C = 23 %
- Communicating E = 18 % and 19 %

This indicates that E group performed slightly better than C for Recall, C performed better than E for the remaining two. However, the differences were not statistically significant as alluded to earlier.

4.2.2.1 Discussion of the Recall theme.

In the recall theme, of the water pollution achievement test (WPAT) the learners were presented with questions in which they had to use prior knowledge of water pollution. The results, per item, are presented in Table 4.3. The learners' performance on these items indicates that the two groups have little understanding of water pollution. Their correct responses range between 18 % and 36 % for E and 14 % and 37 % for C. The sequence of correct scores on the recall items are as follows.

In questions 1.1 and 1.3 they were provided with pictures of a polluted river (river A) and a relatively clean river (river B). The polluted river displayed dead trees and the water appeared murky whereas the clean river's water was clear and contained no strewn objects.

- Item 1.1: Consider the picture and list the possible causes of water pollution in river A. Ranked as 1 and 2 for E and C i.e. 36% and 31 % respectively. They had to observe and recall the contributors of water pollution. Their answers revealed that they knew what they were talking about. They reasoned mostly along the lines of household rubbish being dumped in rivers. For example E_2 and C4 answered as follows:

  E_2: There are dead trees and plastic (bottles and bags) in the river.

  C_4: There are chemical poisons in the river.

C_4 mentioned that the river contained chemical poisons, which was a rare answer to this question. On requiring how she knew that, she replied that she lived in a nearby farm and that the vineyards were often sprayed with chemical poisons. At home they were taught not to drink from the river water or to swim in the rivers. Although she did not know how the chemicals got into the river, she expressed knowledge that she gained from her community. In terms of TAP some warrants or grounds were posited to support the claim she made during the conversation I had with her. In terms of CAT her home-based worldview was dominant while the scientific view was largely suppressed at the pre-test stage.

- Item 1.3: How can a river be kept clean as illustrated by river B? Ranked 2 for E and 1 For C i.e. 33% and 37% respectively. Their answers revealed some prior knowledge from previous grades.

  E_3: They can erect a notice board forbidding refuse dumping.

  C_1: To not allow swimming in it.
- Item 1.9: Who's responsible for the control of water pollution, ranked 3 for both E and C i.e. 27 % and 24 %, respectively. They mostly said everyone is responsible.

  C_4: the department of health.
- Item 1.7: Suggest solutions to water pollution ranked 4 for both E and C i.e. 24% and 22% respectively.

  E_7: Get the community involved in cleaning up operations.

  C_3: They should erect a fence along the river.
- Item 1.8: Does household chemicals cause water pollution. The lowest score of the correct response, 18 % and 14 % from E and C was obtained.

  E_8: No, it is disposed of via the drain system.

  C19: Yes, the contents are poisonous and can kill fishes and other animals.

The response of E8 suggests that he was not aware of the possibility that poisonous substances disposed through the drainage system could get into rivers and perhaps dams and consequently result in environmental hazards. C19 on the under hand was well aware of such a possibility thus providing some evidence for his claim.

4.2.2.2 Applying knowledge

Science knowledge is at best admirable and plausible, but the application of such knowledge is crucial in creating a safe and sustainable environment. The results in Table 4.3 are examined for comparison of the two groups in the applying knowledge theme. This table reveals that the C group outperformed group E in all the items except items 1.2 and 3.1. Groups E and C's overall performances on this theme were 21% and 23% respectively. The low scores obtained by the learners further suggest that they could not apply their knowledge about water pollution adequately. The sequence of correct responses on the applying knowledge theme in a descending order is as follows:

- Item 3.3: What diseases can you get if you drink the untreated water, attracted the highest correct responses, ranking one for both group i.e. 48% and 40% for C and E respectively. Their scores are relatively high compared to the other items in this theme. This could be due to their prior knowledge learnt at primary school level regarding the dangers of water pollution. The following excerpt displays their conceptions:

  C_{12}: You can get cholera, diarrhea and severe stomach cramps from it.

- Item 1.2: Why is fishing not allowed, attracted very low scores for both groups. Their responses ranked two for E and C i.e. 25% and 22% respectively. They displayed various misconceptions, such as:

  C_{15}: It is very dangerous because the water seems deep.

  E_{16}: The water is deep and one can drown in it.

- Item 3.4: Is clean river water safe? The correct responses were 3% and 5% for E and C respectively. They understood clean water as being free of refuse (plastic bags, bottles etc.) and therefore misinterpreted the question completely. Some of their responses are:

  C_{18}: Yes, you can see whether the river is clean or not.

  E_{20}: It means that there is no rubbish, plastic cans etc. in the river.

The low average percentages for both groups indicate that the learners could not apply their knowledge about water pollution sufficiently. Their frequent use of refuse removal or cleaning up operations as the only solutions to the problem of water pollution is a practice they were probably aware even before attending school.

4.2.2.3 Communicating knowledge

In this section learners were provided with a picture of a tributary of a river running through an informal housing suburb. The surrounding area displayed many possible pollutants. They were also told that the water quality of the river revealed the presence of many pathogens and are now required to give explanations for this situation to the community forum.

A close examination of Table 4.3 reveals that the learners displayed very little communicating skills. Their correct responses range between 5 to 25% and 10 to 33% for E and for C respectively. The average percentage of correct responses for E and C were 18% and 19%. The sequence of correct scores is as follows:

- Item 4.2: How hazardous are pathogens? Learners obtained the highest percentage of correct responses, i.e. 25% and 33% for E and C respectively. They seem to realize the dangers of polluted water.

  E_1: People can get diarrhea, stomach cramps and even be hospitalized.

  C_2: People can die.

- Item 4.1: What are the possible causes of the pathogens (bacteria etc.). This item ranked two for both groups attracting 23% and 15% for E and C respectively. As alluded to before learners reasoned in terms of rubbish that was insufficiently dumped.

  E_3: People dump their rubbish in the river.

- Item 4.3: How can the pathogens be minimized? Here they scored 5% and 10% for E and C respectively. It is clear that they have a poor conception of pathogens. The following excerpt illustrates this:

  E_{13}: Supply the houses with taps.

It is evident from the low average percentage for this theme that the learners could not communicate knowledge about pathogens adequately. Perhaps they had no prior knowledge of bacteria, viruses etc.

4.2.3 Research Q 3: Are the learners' conceptions of water pollution related to gender, age or socio-cultural backgrounds?

Table 4.3.2: Learners' pre-test performance on the WPAT according to age.

Age range	N	Mean	Mean %	SD	t-test
15-16	20	14.5	24.08	3.02	t_{obs} (3.35) > t_{crit} (1.684)
17-18	22	11.5	19.24	2.79	
Total	42	12.93	21.55	3.22	

At $p = 0.05$

Surprisingly the younger group performed better than the older group. The difference between the groups is statistically significant (t_{obs} (3.35) > t_{crit} (1.684). The older group consists mainly of learners that are repeating the grade. This finding is similar to an earlier study where on several topics tested the younger learners outperformed their older counterparts (Ogunniyi, 1999). It could also be due to many factors of which one might be attitude. According to Kasanda (1996), attitudes play an important role in the teaching and learning process. He further asserts that attitudes can be developed, modified or be changed. Attitudes are integrally link to one's social milieu. It was my intention to also investigate whether argumentation based instruction could change learners' attitude towards science, resulting in better scores at post-test stage.

4.2.4 Summary

The pre-test quantitative data, corroborated the null hypothesis posited that there will be no difference in the scores of the two groups in terms of their conceptions of water pollution. Most learners perceived, rubbish dumping, as the only form of water pollution. The low performance in the WPAT is indicative of the aforementioned or prior learning.

4.3 Post Test

At the end of the implementation period, the two groups were subjected to the WPAT as a post-test. In a study where the post-test differs from the pre-test, it is dubitable whether the measuring instrument reflects the same underlying conceptualization and thought processes in the post-test as in the pre-test, and hence my use of the same WPAT for both pre- and post-test. As stated earlier, groups E and C wrote a pre-test. Group E was exposed to the treatment, i.e. argumentation based instruction while group C was exposed to an alternative expository method with occasional teacher demonstration. The null hypothesis posited for testing was that there would be no difference in the performance of the learners exposed to argumentation based instruction and those not so exposed. The learners' performances are displayed in Table 4.4.

4.3.1 Post-test statistical summary.

Table 4.4: Learners' performance on the WPAT at the post-test stage:

Group	N	Mean	Mean %	SD
E	21	24.86	41.43	2.3
C	21	17.1	28.49	3.65
	t_{obs} (8.3) > t_{crit} (1.684)			

The above table represents the average performance of groups E and C. Looking at the overall picture, although no group achieved a mean % of above 50%, the group that performed the best was E with a mean % of 41% and C 28%. The t-statistic for E and C is 8.3 which is higher than the critical value of 1.684 at p = 0.05. In other words, the null hypothesis suggesting no performance difference between the two groups is rejected. There is a significant difference in performance of the E and C learners taught by argumentation-based and expository methods respectively. This implies that the dialogical argumentation instruction used for E has potential for enhancing learners' conceptual understanding and hence worthy of consideration by researchers seeking to improve learners' understanding of various scientific concepts.

4.3.2 Data collected at the post–test stage.

Judging by the means of the pre-test of about 21.3% for E and 21.8 % for C and the post-test mean scores of about 41% (E) and 28% (C), one can see a difference between the means of the two tests for both groups at the post-test stage.

Table 4.5: Pair-wise Comparison of the scores at the pre- and post-test stages

	Group E		Group C	
	Pre-test	Post-test	Pre-test	Post-test
N	21	21	21	21
Mean	12.76	24.86	13.05	17.1
Mean %	21.27	41.43	21.75	28.49
SD	2.18	2.3	4.05	3.65
t-test	t_{obs} (2.19) > t_{crit} (1.725)		t_{obs} (0.884) < t_{crit} (1.725)	

Significant at p = 0,05

Obtaining a t-value of 2.19 and 0.884 for the E and C groups for the pre- and post- test scores against a critical value of 1.725 is indicative of significant difference for E, but not for C between the pre-and post-test mean scores. This implies that the null hypothesis has to be rejected for E, as there is a significant difference between the two tests. However, null hypothesis for C cannot be rejected. Since both groups were exposed to the same teaching and learning materials, (except for the argumentation based instruction (ABI) for E), the higher t-value was probably as a result of the argumentation model learners in that group were exposed to. As one of the E learners said, “My opinion is valued in argumentation.”

It is apposite to mention that C group was not left to its own devices in that it was exposed to some exemplary instructional materials and experiments.

4.3.3 Data collected from the WPAT at the post-test stage.

The learners performed much better for the selected process skills (recall, applying knowledge and communicating) at the post-test stage. Their responses displayed a greater understanding of water pollution. The selected process skill recall had the most correct responses at the post-test stage followed by applying knowledge then communicating knowledge.

For ease of reference and comparison, the post-test for the three groups were analysed item by item using the percentage of correct responses, which were arranged in a descending order. In Table 4.6 the learners' performances range between 23% and 65%, 19% and 51% for E and C respectively at the post-test stage. Item 4.3, "How can the pathogens be minimized?", from the selected process skill communicating knowledge, attracted the least correct responses, i.e. 23% and 19% for E and C respectively. Item 1.7, "Suggest solutions to water pollution", from the selected process skill recall, attracted the most correct responses, 65% for E. Item 1.3, "How can a river be kept clean", attracted the most correct responses, 51% for C. It is clear that E outperformed C on all the categories. For ease of comparison the pre- and post-test scores are presented in Table 4.6.

Table 4.6 Percentages of Correct Responses to selected Items of the WPAT at the Pre- and Post-test stage.

Water pollution (water poll)

Items	Summary of items	Pre	Post	Items	Summary of items: C%	Pre	Post
	Recall		E(%)				C(%)
1.7	Suggest solutions to water poll	24	65	1.3	How can a river be kept clean	37	51
1.3	How can a river be kept clean	33	59	1.7	Suggest solutions to water poll	22	40
1.1	Possible causes of water poll	36	55	1.1	Possible causes of water poll	31	38
1.9	Who's responsible for the control of water poll	27	46	1.8	Do household chemicals cause water poll	14	37
1.8	Do household chemicals cause water poll	18	45	1.9	Who's responsible for the control of water poll	24	30
Total	Average %	28	54	Total	Average %	26	39

Items	Summary of items	Pre	Post	Items	Summary of items: C%	Pre	Post
	Applying knowledge		E(%)				C(%)
1.2	Why is fishing not allowed?	25	59	3.3	What diseases can you get if you drink the untreated water?	48	45
3.3	What diseases can you get if you drink the untreated water?	40	54	1.2	Why is fishing not allowed?	22	43
3.2	How will you purify the water?	14	48	3.1	What do you think are the causes of them feeling sick?	21	33
3.1	What do you think are the causes of them feeling sick?	21	44	3.2	How will you purify the water?	18	25
3.4	Is clean river water safe?	3	28	3.4	Is clean river water safe?	5	19
Total	Average %	21	47	Total	Average %	23	33

Items	Summary of items	Pre	Post	Items	Summary of items: C%	Pre	Post
	Communicating		E(%)				C(%)
4.2	How hazardous is it?	25	52	4.2	How hazardous is it?	33	37
4.1	What are the possible causes of the pathogens (bacteria etc.)	23	38	4.1	What are the possible causes of the pathogens (bacteria etc.)	15	26
4.3	How can the pathogens be minimized?	5	23	4.3	How can the pathogens be minimized?	10	19
Total	Average %	18	38	Total	Average %	19	27

4.3.3.1 Recall

During the post-test stage there was an improvement in most of the items compared to the pre-test stage. Although this was the case, item 4.3, dealing with, "How can the pathogens be minimized?" still attracted the least correct responses 23% and 19% for E and C respectively. The learners still struggled with the concept of pathogens. Item 1.7, dealing with "suggest solutions to water pollution", attracted the most correct responses 65% for E and item 1.3, dealing with "how can a river be kept clean", the highest for C. The sequence of correct scores on the recall items are:

Item 1.3 is concerned with finding out the learners' conceptions of river pollution depicted by two examples: one polluted water and the other a relatively clean and well managed river. The learners' responses reflect various perspectives which have implications for TAP and CAT. For example E7 suggests the need for children not to throw litter into drinking water.

- Item 1.3: "How can a river, be kept clean", ranked 2 for E and 1 For C respectively, showing an improvement in performance from 33% to 59% and 37% to 51% for E and C. Their answers revealed some progression.

  Pre-E_7: Children should not litter.

  Post-E_7: Enforce the law by issuing hefty penalties.

In terms of TAP, the claim made by E7 in the pre-test regarding children not littering their surroundings, is not supported by any evidence. This statement just reiterates their prior knowledge. At post-test E7 reflected a deeper conceptual understanding of how to solve the problem of water pollution. E7 gave evidence that by enforcing the law the river can be kept cleaner than it was. This illustrates that E7 has developed some level of argumentation skills after being exposed to ABI.

The C group learners gave the following answers:

Pre-C3: Dumping refuse should be prohibited.
Post-C3: Disconnecting pipes running from factories.

Although the answer of C3 is partially correct, no evidence is provided to support his claim. The post-test response is just another claim without any evidence he is simply recalling another contributor of water pollution. In terms of TAP these claims can be regarded as non-oppositional in that they lack sufficient grounds to justify them. However, in terms of CAT these claims may also have emanated from learners' cultural experiences. In the indigenous communities children are taught from an early age to respect community water sources. In fact in certain indigenous communities, sources of water are given the status of taboos. People are not allowed to litter, urinate or pass faeces around water sources.

- Item 1.1: 'List the possible causes of water pollution'. Ranked as 3 for E and C improved from 36% to 55% and 31 % to 38% respectively. Their responses improved in quality. For example learner E_{20} answered as follows:

Pre-E_{20}: The river has bottles and plastic bags in it.
Post-E_{20}: There might be orchids next to the river and the trees are sprayed with pesticides, which end up in the river, thus causing water pollution.

The learner's pre-test response shows his prior knowledge since the picture does not show any bottles or plastic bags in it. The post-test response reveals a conceptual understanding of agricultural run-off causing water pollution. The learner claims that pesticides end up in the river and causes water pollution. From the above it is evident that the E learners made claims and supported it by evidence. In terms of CAT it is safe to state that the "emergent schema" in favour of science has occurred.

- Item 1.9: "Who's responsible for the control of water pollution", ranked 4 and 5 for E and C respectively. They showed an improvement from 27% to 46% for E and 24% to 30% for C. Learners' responses were better as the following excerpt illustrates.

  Pre-E_{13}: The department.

  Post-E_{13}: Everyone should be cleaning up no one can be excluded, since we are all dumping waste.

At pre-test the learner places the responsibility of maintaining clean rivers as the task of the municipality. He distances himself from his responsibility that echoes the position of communities. Communities are not taking ownership of their resources. However, rural communities keep their own water resources clean. They do not see themselves to be separate from the world in which they find themselves, but as part thereof (Ogunniyi 1988).

- Item 1.8: "Do household chemicals cause water pollution", ranked 5 and 4 for E and C, which showed an improvement from 18% to 45% for E and 14% to 37% for C.

Learner E4 (pre): No, most household chemicals help to clean dirty water like jik.
Learner E4 (post): Almost all household chemicals are poisonous and should be handled with caution.

E4 related to what she knows from back home where the river water is always first purified by adding a little bit of jik. In terms of CAT at pre-test E4's traditional worldview is dominant and at post-test her scientific worldview falls into the emergent category. The learners' stances towards household chemicals are altered and the misconception addressed.
Looking at the overall performance of the two groups, 54% and 39% for E and C respectively, E definitely outperformed C.

4.3.3.2 Applying knowledge

The results in Table 4.6 are examined for comparison of the two groups relative to applying knowledge theme. This table reveals that the E group outperformed group C in all the items. Group E and C's overall performances on this theme were 47% and 33% respectively. The scores obtained by the learners further suggest an improvement from the pre-test to post-test stage, i.e. 21% to 47% for E and 23% to 33% for C.

The sequence of correct responses on the applying knowledge theme in a descending order is as follows:

- Item 1.2: "Why is fishing not allowed?" improved from 25% to 59% and 22% to 43% for E and C respectively, ranking them one and two. An improvement in the responses:

  Pre-E3: There are no fishes in the polluted water for they are dead.

  Post-E_3: The fishes might be poisoned, because of chemical waste that can be found in rivers that is located in the vicinity of factories.

This learner's pre-test response shows that, he probably knew about it and only stated a claim without giving any reasons. At post-test the learner provided a reason and one can observe a conceptual change.

- Item 3.3: "What diseases can you get if you drink the untreated water?", improved from 40% to 54% for E and decreased from 48% to 45% for C, ranking two for E and one for C.

  Pre-E15: Stomach cramps and diarrhea.

  Post-E15: Cholera that can lead to death if it is left untreated.

The learner's responses indicate that she is well aware of the effects of drinking polluted river water.

- Item 3.2: "How will you purify the water?", improved from 14% to 48% for E and 18% to 25% for C, ranking three for E and four for C.

Here a few examples of the learners' responses to Question 3.2: asking, "How will you purify polluted river water?"

> Pre-C11: By keeping the river clean, removing debris.
> Post-C11: By using chemicals to clean the water.
> Pre-C5: I will first boil the water, let it cool down and then store it in the fridge.
> Post-C5: Boil the water and add salt to it to destroy organisms.

There was progression in the answer given by C11, but again no evidence is provided for the claim. C5 also used her everyday knowledge, but gives the wrong scientific explanation for destroying organisms, a clear misconception. When I examined the responses among learners in the E group for the same question the following responses were given:

> Learner E3 (pre): Boil the water and let it stand.
> Learner E3 (post): Use a filtering system to remove dirt. Boil the water to kill the germs in it and then add a little jik to sterilize the water.

E3's pre-test response shows that she had seen people boiling water as a means to purify it. However, in terms of TAP, she does not give any valid reason for this claim. The post-test response shows that she knows the steps involved in purifying polluted river water and evidence for the claim such as filtering, boiling and adding jik to the water. In terms of CAT, E3 knows the importance of boiling the water do kill most of the germs in the polluted water. Learners come to the science class with knowledge of purifying water that they acquired through performing household chores. They are familiar with the process of allowing the water to stand so that sediments can settle at the bottom of the container. In terms of CAT both the science and IKS-based knowledge have been mobilized to provide grounds for the claims made by the learners.

- Item 3.1: “What do you think are the causes of them feeling sick?”, ranking four for E and three for C, improved from 21% to 44% for E and 21% to 33% for C. Some excerpts to illustrate their answers.

  Pre-E_3: The water contains too much rubbish.

  Post-E_3: Can be due to bacteria in the water because it was not purified.

The learner’s answer reveals a better understanding of water pollution at post-stage.

- Item 3.4: “Is clean river water safe?” ranking fifth for both groups. The scores improved from 3% to 28% for E and 5% to 19% for C.

  Some of their responses were:

  Pre-E_{11}: No, you do not know what people throw in water.

  Post-E_{11}: No, different harmful organisms live in river water, therefore the water must be purified.

Question 3.4: Many people assume that “clean” river water is safe. Do you agree? Give reason(s) for your answer.

E3: Pre-test: Yes, then you can see whether there are broken glass in the water.

E3: Post-test: No, because a variety of organisms live in the river water it is essential to purify the water.

The average percentages for both groups increased i.e. a manifestation of emergent categories of CAT in favour of what has been learned most probably through science. The above excerpts are indicative of, the quality of answers, group E learners’ provided. They demonstrated a better understanding of the complexities of water pollution.

4.3.3.3 Communicating knowledge

A close examination of Table 4.6 reveals that the learners displayed better communicating skills at the post-test stage. At the pre-test stage they struggled mostly with item 4.3: “How can the pathogens be minimized?” The overall performance improved from 18% to 38% and 19% to 27% for E and C respectively. The learners’ performance at the post-test stage ranged between

23% to 52% and 19% to 37% for E and C respectively. Item 4.3: dealing with "How can the pathogens be minimized?" attracted the least correct responses of 23% for E and 19% for C.

The sequence of correct scores is as follows:

- Item 4.2: How hazardous is pathogens? Learners obtained the highest percentage of correct responses, i.e. 52% and 37% for E and C respectively. They seem to realize the dangers of pathogens in polluted water.

  E_5: In rural areas people collect their water from rivers and add bleach (jik) to it, to kill the bacteria.

  E_{18}: You can get cholera from stagnant water.

- Item 4.1: What are the possible causes of the pathogens (bacteria etc.). This item ranked two for both groups it improved from 23% to 38% and 15% to 26% for E and C respectively.

  E_{10}: Human waste. The council should erect toilets for each household and this in turn will prevent people from using the rivers as dumping sites for sewage.

Learners were not afraid to voice their opinions as the above excerpt clearly illustrates.

- Item 4.3: How can the pathogens, be minimized? Their scores improved from 5% to 23% for E and 10% to 19% for C.

  The following excerpt illustrates this:

  E_8: Stop or minimize water pollution. Secondly disinfect water before using it.

In all the items, group E outperformed group C.

4.3.4 Comparison of pre and post-test

Figure 1 below represents the process skills demonstrated by learners at the pre- and post-test stages. Each column represents the process skills used to perform cognitive tasks on the WPAT. Group E shows an improvement in performance in the recall category from 28% to 54% while C improved from 26% to 39%. The improvement of C can be attributed to the lecture method. The performance of E can thus be attributed to argumentation based instruction.

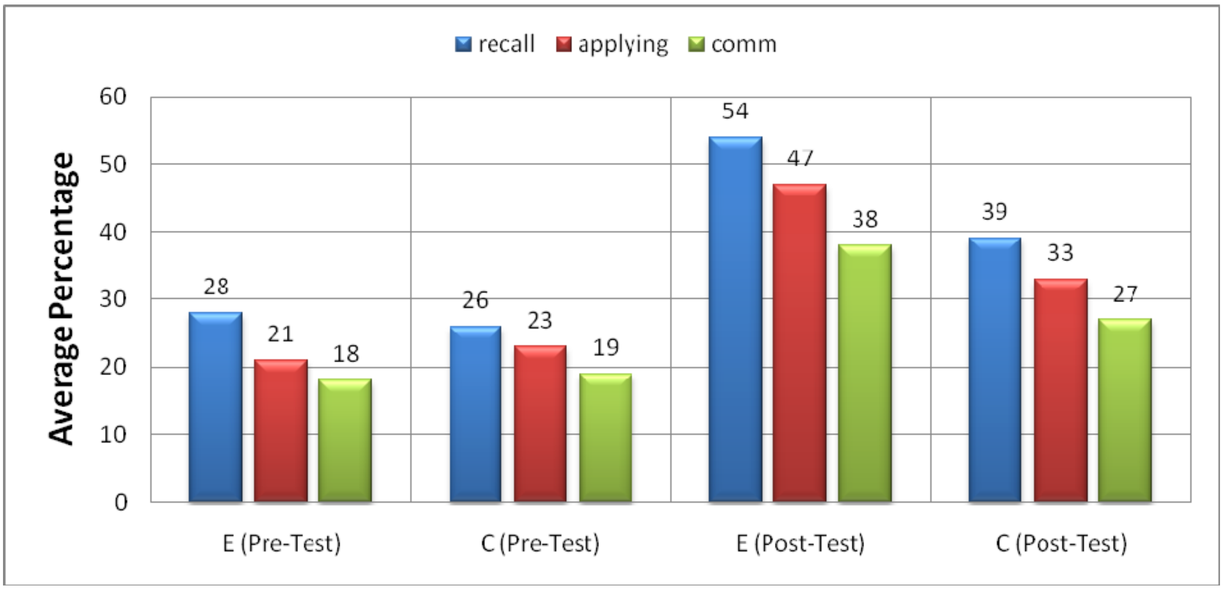

Figure 1: Learners' Performance on the WPAT at the pre and post-test stage.

An examination of the "applying knowledge" column shows that E and C has improved performance from 21% to 47% and 23% to 33% respectively.

In the "communicating knowledge" category, E group has improved their performance from 18% to 38% compared to C whose percentage increased from 19% to 27%.

4.4 Post-test performance according to gender

In an African context the role of women in traditional societies was restricted mainly to that of household chores, society assigned inferior roles to females. Jegede et al (1996), (as cited by Sjoberg, p.240):

> There is a wide gulf between male and female in formal school settings and achievement outcomes. Translated into the classroom situation, it is not difficult to imagine how the societal views about the role, capability and capacity of females might affect their interest, achievement and attitude to STM.

While Jegede's (1996) view might be true in certain cases, i.e. that female gender role tends to limit girls' expectation or exert negative influence on their expectations, the findings of this study suggest contrary. There is no significant difference between the performance of females and males involved in this study whether at the pre-test or the post-test. Again, this finding corroborates an earlier large-scale study carried out in the Western Cape (Ogunniyi, 1999).

Table 4.7: Learners' performance at the pre- and post-test stages according to gender.

Gender		N	Mean	Mean%	SD	t-test
Female	Pre-test	20	13.35	22.25	2.3	t_{obs} (1.13) < t_{crit} (1.684)
Male		22	12.5	20.83	2.57	
Female	Post-test	20	21.7	36.2	4.8	t_{obs} (0.901) < t_{crit} (1.684)
Male		22	20.32	33.9	5.05	

It is worth noting that though the differences in performance between the girls and the boys are not statistically significant; the girls seem to obtain higher mean scores at the pre- and post-test stage (see Table 4.7 above). However, only a small percentage of girls pursue careers in science and technology (Ogunniyi, 1999). Although this is not the focus of this study it might be an interesting endeavour to explore further the career aspirations of these high performing girls. Though our general expectation that boys were likely to perform better than girls in science seems unjustified it has been confirmed in a plethora of earlier findings studies as well as the historically male dominated nature of science and the language of science instruction (Afonso & Ogunniyi, 2010; Ogunniyi, 1999; Sjoberg, 1996). This stance is expressed in Sjoberg's (1996) article as follows, "Science is a man-made activity in a literal sense".

In a summary of research findings (Taiwo, 1996) asserts:

> That the male tends to be more positively inclined to science-related careers than his female counterpart, to the extent that the majority of the male exhibit liking of careers in engineering, medicine, aeronautics and agriculture while a preponderance of their female counterparts exhibit inclination toward care-giving careers such as nursing, social work and catering. (p.66)

According to Ogunniyi (1999) the smart girls tend to prefer the softer sciences or change their career paths by entering the corporate world rather than science.

4.5 Learners' performance on the WPAT according to age.

Table 4.8: Post-test performance on the WPAT according to age.

Age range	N	Mean	Mean %	SD	t-test
15-16	20	21.2	35.25	4.83	t_{obs} (0.797) < t_{crit} (1.684)
17-18	22	19.9	33.11	5.67	
Total	42	20.48	34.13	5.26	

At p = 0.05

The younger age group (15-16 years) has performed better than the older group (17-18). Surprisingly the younger group performed better than the older group. The difference between the groups however, is not statistically significant (t_{obs} (0. 797) < t_{crit} (1.684).

The literature seems to suggest that interest in science and consequently performance tends to decline with age both among boys and girls but more among girls.

Table 4.9: Post-test performance on the WPAT according to gender and age.

Age range		N	Mean	Mean %	SD	t-test
15-16	Boys	9	21.1	35.2	4.3	t_{obs} (0.584) < t_{crit} (1.725)
17-18	Boys	13	19.8	32.95	5.6	
15-16	Girls	11	23.1	38.5	3.17	t_{obs} (1.47) < t_{crit} (1.734)
17-18	Girls	9	20.0	33.3	6.1	

At p = 0.05

Comparing older age groups with younger ones for both sexes do not show a statistically significant difference between the groups, as table 4.9 shows.

4.6 Research Question 4: Is there any difference in the performance of learners exposed to an argumentation- based instruction and those who have not been so exposed?

Relative effectiveness of the treatment.

The fourth research question stated in chapter 1 is concerned with finding out the effect of the treatment, i.e. argumentation-based instruction on the learners understanding of water pollution.

The purpose of the pre-test was to determine the nature of the learners' conceptions of water pollution as well as areas where they had poor understanding of concepts. The experimental group was exposed to a three week treatment involving the use of Toulmin's argumentation Pattern (TAP). Also, both groups E and C, were supplied with instructional material on water pollution as well as samples of clean bottled water, polluted river water and clean tap water to which a few drops of ammonia was added.

4.6.1 The effect of Argumentation-Based instruction (ABI)

The use of argumentation was influenced by a shift in the way learning is viewed, away from seeing it as happening in the individual mind towards one involving social and cultural processes. Language plays a very important role in learning, as it is through language that indigenous knowledge are passed on to learners (Vygotsky 1978, Lemke 1990, Wertsch 1991). Similarly, according to Lemke (1988, p. 81), '"The mastery of academic subjects is the mastery of their specialized pattern of language use". From this socio-linguistic perspective, learning within a discipline requires adopting the norms of the language of that discipline. Learners must become familiar with the terminology used in science. The language of science is a technical language and is not exactly, in most cases, as the common everyday language used by the learners (Ogunniyi, 1999). This can be achieved through their participation, through expressing their ideas, in deliberations with others and making sense of scientific occurrences to which they are being introduced (Driver et al. 1994).

It was also used as a method to show how scientists use argumentation to either accept or refute ideas (Popper, 1959).

The historically depriving teaching method i.e. lecture method minimizes learner participation. It was for the same reason perhaps that some researchers have used TAP, an argumentation model to determine the teachers' and learners' understanding of the nature of science (e.g. Driver et al,2000; Erduran et al,2004; Ogunniyi, 2004, 2006, 2007 a & b; Osborne et al, 2004; Simon et al, 2006). These investigators have found argumentation and dialogue to be a useful tool for enhancing teachers' and learners' conceptual understanding. The use of ABI seemed to have achieved the desired effect as it is reflected in the post-test results.

4.6.2 Reflection on whole class discussion about water pollution.

Lesson content was the same for both groups. The learners in the experimental group were presented with samples of polluted river water and also given worksheets that contained individual activities and group activities. These activities were used to capture their discussions about their observations.

To gain an insight and share the various ideas that emerged from small group discussions whole class sessions were facilitated. In these sessions, groups had the opportunity for arguments and dialogues in order to reach some consensus where feasible (Erduran et al. 2004). Some of the responses are reflected on:

Teacher: What are the sources of pollutants?
Learner group 1: Refuse dumping.
Teacher: Is that the only source of pollution? Give a reason for your answer.
Learner group 2: No, point source dumping poses a serious threat.
Teacher: What do you mean by point source dumping?
Learner group 2: It is a single point of pollution that is observable e.g. pipes discharging effluent from factories.
Teacher: Can this serious threat of effluent dumping from factories, water treatment plants, etc. be stopped.
Learner group 3: Yes, all contributors of such waste should be closed down.
Teacher: How are we going to manufacture goods that are necessary for our existence?
Learner group 1: We must live without it.
Teacher: Give a workable solution to this problem.
Learner group 3: The contributors of such waste should first recycle it. Treat it appropriately and then test samples of the treated waste before it is discharged into rivers.

It is clear that the learners used argumentation to substantiate their claims. Learner group 1 gave only the answer. After prompting them to give reasons they responded with good quality arguments. They participated actively in discussions and the time seemed to pass very quickly. One of the learners expressed afterwards that he thoroughly enjoyed the lesson.

4.6.3 Integration of Indigenous and Western Sciences

Integration of indigenous and western sciences will vary depending on the content to be taught. An attempt to transform a western science ecology curriculum into a Canadian Aboriginal curriculum failed. The Aboriginals developed their own curriculum, practising the Law of Circular Interaction (Sakatchewan Indian Cultural Centre, 1993). A simple transformation from one system to another is often not feasible (McKinley, 2005). Thus the integration can fail depending on the context.

Curriculum 2005 (C2005) for the Natural Sciences asserts that:

> There are other worldviews. For example, in South Africa many people hold a strong world-view which says that people are not separate from the earth and its living things; they believe that all things have come from God or a creative spirit and therefore have a spiritual meaning; events happen for spiritual as well as physical reasons . . . People tend to use different ways of thinking for different situations, and even scientists in their private lives may have religious frameworks or other ways of giving values to life and making choices . . . One can assume that learners in the Natural Sciences Learning Area think in terms of more than one world-view. Several times a week they cross from the culture of the home, over the border into the culture of science, and then back again (Department of Education 2002, 11-12).

4.7 Learners' opinions about an argumentation-based instruction (ABI).

Classroom deliberations in the experimental group shed some light on the value of TAP as a tool in quantifying arguments. Question 3 of the instrument was used to interrogate learners' traditional knowledge/IKS about purifying polluted water.

Since ABI was new to the learners, I wanted to get their feedback on this method of instruction. During the focus group interview, the learners were asked to express their views about ABI to which they had been exposed. The focus group interview schedule included some features of the questionnaire on students' perception of argumentation based instruction. The excerpt below reflects their views on an argumentation-based instruction:

Teacher: Have you received instruction on water pollution in previous years?

Learner 1: Yes, at primary school level.

Teacher: Do you think argumentation based instruction is lively and interesting?

Learner 4: Definitely, almost everyone comes alive and is contributing to the lesson.

Learner 6: It could be a bit noisy at times.

Teacher: Is the noise a problem?

Learner 4: No, It's better than just listening to a tedious lesson.

Teacher: What aspect(s) of the argumentation based instruction did you enjoy or disliked.

Learner 2: My voice is heard in the group and my opinion valued.

Learner 3: The group members helped each other and that causes a sense of belonging.

Learner 5: Some members try to dominate the discussion.

Learner 3: That did not stop me from contributing.

Teacher: Is argumentation based instruction not too time consuming.

Learner 1: No, it is much better than just taking down notes all the time.

Learner 6: In a normal lesson we are not engaging enough.

Learner 2: Teachers do all the talking.

Teacher: Do you think argumentation based instruction helped you to understand science better.

Learner 5: It has changed my attitude towards science, science is not dead….maybe I can become a scientist one day.

Learner 4: What I like about argumentation is that you get a chance to reason. The emphasis is not only on providing right or wrong answers.

Teacher: In Closing, do you think argumentation-based instruction should be used in a science classroom?

Learner 1: Yes, it is helpful.

Learner 2: You learn from others.

Learner 3: The teacher is not solely in charge and everyone is busy.

Learner 4: Teamwork is encouraged.

Learner 5: I am forced to use my head.

Learner 6: It is much better.

The above dialogue indicates that learners find the lecture method tedious and it seems as if as far as these learners are concerned, an argumentation-based instruction is more effective in its goal to provide them a learner-centered environment. An environment where learners are heard and not silenced or an environment where they can actively participate in dialogue. Learners' opinions are valued and they do not fear ridicule. Consequently the anguish they harboured about science diminished.

My observations of small group activities indicated that learners felt at ease expressing themselves and even differed with their peers. The fear of being right or wrong was not present, they challenged each other. This is contrary to a traditional classroom where learners rarely participate because of fear that they will provide wrong answers. I reminded them that each claim should have data, substantiating the claim or a rebuttal refuting a claim.

4.8 Summary of the Results.

1. At pre-test stage there was no significant difference between the scores of the experimental (E) learners and control (C) learners.
2. At post-test stage there was a significant difference between learners exposed to the treatment, i.e. argumentation-based instruction (E) and those exposed to talk and chalk method.
3. The experimental group learners performed better than the control group learners.
4. The experimental group learners achieved higher scores than the control group learners for the selected process skill, recall with an average of 54% and 39% for E and C respectively.
5. On the process skill, application, the E group scored an average of 45% and the C group 33%.

6. On the process skill, communicating, the E group scored an average of 38% and the C group 27%.
7. There was no significant difference between the scores achieved by the boys and those of the girls, although performance seemed to favour the girls.
8. The majority of the learners claimed that argumentation-based instruction improved their understanding of water pollution.
9. The learners exuberant responses during the ABI lessons and evident from the focus group interview they seem to have enjoyed the ABI.

4.9 CONCLUSION

The results synthesized in this chapter point to pockets of positive results in this emerging complex field of cultural studies in science education. In agreement with earlier studies, it seems that learners' interests, self-esteem, achievement and empowerment can be augmented by a cultural approach to school science as has been attempted in this study through an argumentation-based instruction. But in view of the challenges posed by this approach to present school time table, a creative way is needed to get a more positive result than has been the case in this study. However, the positive indicators evident in the results hold promise for future work in the area. It is apposite to mention that most science teachers do not appreciate the fact that the vast majority of their learners see school science as a foreign type of culture. To be at ease with school science learners must cross cultural borders and form new self-identities to achieve the goals depicted in the new South African science curriculum. Curriculum policy in support of humanistic cross-cultural learning is already in place, but teaching materials are still being developed. Teacher development requires considerably more attention, but we can be encouraged by recent action research studies (Ogunniyi et al, 1995; Ogunniyi, 2004).

CHAPTER 5
CONCLUSION, IMPLICATIONS AND RECOMMENDATIONS

5.1 INTRODUCTION

The main goal of this study was to explore grade 10 learners' conceptual understanding of water pollution, using argumentation-based instruction (ABI) as a teaching tool. In addition the effects of gender and age on the learners' conceptual understanding of water pollution were examined. In chapter one, the questions pertaining to this study were raised. In chapter two, the theoretical framework in which the study was situated was discussed in detail while in chapter three the methodology used in collecting the data are described. In chapter four, the results based on the quantitative and qualitative data were analyzed and discussed. This chapter summarizes the major finding and examines the implications of such findings for curriculum development and instructional practice. Finally, the chapter offers some suggestions for various stakeholders.

5.2 FINDINGS

As outlined in chapter three, two groups of grade 10 learners consisting of the experimental group (E) and the control group (C) participated in the study. Groups E and C wrote a pre-test, E was exposed to ABI while C the control group was not so exposed. The major findings of the study are presented below:

- The pre-test was administered before any lesson on water pollution was done i.e. right at the start of the research. Based on the pre-test data, there was no significant difference between the performances of groups E and C, i.e. they were quite comparable. Learners' responses to the Water pollution Achievement Test (WPAT) suggested that they had prior knowledge of water pollution. However, the level that they had indicated a low-order process skills such as recalling and classifying but not higher-order cognitive categories like applying and communicating valid knowledge. Some of the learners knew how polluted water are purified and could describe the important steps in the cleaning process. In terms of CAT certain suggestions they made most probably came from the knowledge they had acquired in their traditional communities e.g. they were familiar with the use of a clean cloth to filter river water to remove dirt. When I used a paper filter during one of the lessons they related it to the cloth filter in their cleaning process at home. The use of jik and chlorine tablets as sterilizing agents was well known among learners coming from rural areas. At other times their knowledge probably came from what they had already learned in the lower classes as well as the argumentation-based instruction to which they had been exposed in the course of this investigation. Nevertheless, it is safe to state that these learners have acquired a rich store of knowledge that they could draw upon in tackling various socio-scientific issues that impinge on their daily lives. Unfortunately in a normal class dominated by the lecture method learners are not able to discuss and share their ideas with others. Often, opportunities for the co-construction of knowledge, is consequently lost.

- At the post-test level, however though there was an improvement in the performance in both E and C the former clearly outperformed the latter in most of the items. This was probably due to the fact that E was exposed to an Argumentation-based Instruction (ABI) while C was exposed to the traditional expository lecture method. The significant difference between E and C were therefore attributable to ABI to which the former was exposed.
- Although generally, ABI seems to have had a positive effect on the understanding and learning of the learners, judging by the few negative comments made by teachers in other research instances (Newton et. al., 1999), e.g. teachers' negative views:

  (i) Time constraints and the Curriculum;

  (ii) The difficulties of managing discussion;

  (iii)Teacher skills and views of Science.

  These obstacles can be overcome if the facilitating teacher is properly trained (Ogunniyi, 2007a), lessons are well planned and prepared in terms of appropriate curricular materials and consequently the threat of time can be overcome. The objective of bridging the gap between learners' traditional worldview and that of science should serve as driving force. Creating a classroom that thrives with potential scientists.
- From the analysis of the focus group interview as well as excerpts from Water Pollution Achievement Test (WPAT) it seems clear that the method (i.e. ABI for E) had a significantly positive impact on the learners' understanding of water pollution.
- In both the pre-test and post-test, there was no significant difference between the performances of the girls and the boys involved in this study.

Though not as deep as one would have liked, it is safe to state that the learners involved in the study seem to hold relatively good conceptions of water pollution. Their responses as revealed in the WPAT indicated that, both groups possessed to some degree valid scientific conceptions about water pollution.

When learners involved in the research were exposed to a Science and IKS-based conceptions of water pollution question, they provided responses that surprised me. With a certain amount of confidence they drew upon their own existing conceptions about the workings of the natural world. The finding is also in line with the new South African curriculum policy statement (DOE, 2002) which stresses the need to integrate school science with IKS to draw on the experiences of the learners. The curriculum does not assume that learners come into the science classroom tabula rasa. They do hold valid ideas about causes of water pollution based on the everyday experience at home. Such home-based experiences invariably are drawn from IKS which the curriculum statement regards as the "knowledge reflecting the wisdom and values that people living in South Africa have acquired over the centuries" (Ogunniyi, 2009, p2). According to Ogunniyi (1995) and Aikenhead (1996) a sort of dualism exists in the minds of learners as they cross the physical borders from their home environments into the science classroom. A learner has to resolve the conflict that might arise in his/her mind as a result of inter-action between school science and indigenous knowledge. In view of this border crossing phenomenon, Ogunniyi (1995) contends that a learner's scientific understanding cannot be completely divorced from his/her pre-existing knowledge and worldview.

A cultural perspective in teaching attempts to avoid the enculturation pitfall wherein students are socialized into a particular worldview is what Driver and associates described as "cultural apprenticeship" (Driver et al 1994: 11). For the same reason, various studies that have attempted to change learners' alternative conceptions in favour of science (e.g. Posner et al, 1982) were largely unsuccessful because of their assimilatory rather an inclusivist focus. The meaning of science in school science has now shifted from the conventional western science found in social constructivism to a multicultural meaning –'a rational perceiving of reality' (Ogawa 1995:588).

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

The attempt to include IKS within the science curriculum is not unique to South Africa. It has also been done in North America and Australia and other countries but with a distinct difference in that they “removed specific aspects of indigenous knowledge from their larger context to meet the demands of school science” (Ogunniyi, 2004: 295). Although the new curriculum endeavours to achieve inclusiveness it has not provided explicit guidelines about how to achieve this goal. The integration of two opposing knowledge systems is not easy to achieve (Ogunniyi, 2004), but this obstacle can be overcome with the necessary training of teachers in the protocols of argumentation protocols as has been implemented in this study. In a study undertaken to enhance teachers’ understanding of, and ability to implement, a science/IKS curriculum Ogunniyi (2007) found that by employing a Practical Argumentation Course (PAC) the need for training teachers can be accomplished. However, based on my experience in the study, a long-term mentorship is required for such a training to be successful.

- **Learners exposed to an argumentation-based instruction (ABI) valued the contributions they could make and freely shared ideas with others. ABI gave them a chance to add their home-based knowledge to the science/IKS lesson.**

In the teaching of science argumentation is fundamental to understanding of what science is all about. Learners should be given the opportunity to state a claim, provide grounds and participate in discourse. Findings from several studies have highlighted the importance of arguments and dialogues in enhancing teachers’ and learners’ conceptual understanding of NOS and IKS (e.g., Aikenhead, 1997). As Ogunniyi (2007a) have argued:

> A Science-IKS curriculum that reflects valid images of both systems of thought provides indigenous and non-indigenous students access to different ways of knowing and interpreting experience (p.968).

According to Lawson (2004), effective instruction encourages an atmosphere where ideas are raised and contradicted by evidence and by the arguments of others. Teachers are faced with learners that come to school with different worldviews, and daily cross cultural borders. 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 ABI that the E group learners were exposed to seemed to have enhanced some form of harmonious dualism where the E group learners could hold two diametrically opposed worldviews without experiencing cognitive conflicts (Ogunniyi and Ogawa, 2008). To Ogunniyi (1988, 2007) the attainment of harmonious dualism rather than cognitive dissonance should be an important goal of science education. However, the attainment of that goal to a large extent depends on how well an inclusive science-IKS curriculum has been implemented. Ogunniyi (1988, 1995) has suggested further that harmonious dualism is attained "through conceptual appropriation, accommodation, integrative reconciliation and adaptability. The Contiguity Argumentation Theory (CAT) as espoused by (Ogunniyi, 1997) can be used to explain a scenario where two competing thought systems, science and IKS are placed side by side.

In conclusion, the findings of this study seem to confirm other related studies namely that learners as well as adults hold multiple worldview presuppositions and that, teaching and learning should seek to harness these worldviews so that they can co-exist in a harmonious rather conflicting or irreconcilable way. What is important here as several scholars have pointed out is that learners living with such dualism know when a particular view is more appropriate than another in a given context (e.g. Gunstone & White, 2000; Ogunniyi, 2004, 2007a & b).

In view of the small sample used in this study there is a need to use a bigger sample involving several schools with learners from coming different socio-cultural backgrounds. Also, the duration of the study should be much longer than was the case in this study. A further study also needs to be done on the effect of integrating everyday science with school science. I believe this could be an answer to a lot of problems facing the teaching of science in traditional communities. One of these problems is the phobia that science is a difficult subject meant only for individuals with a high intellect. It is hoped that as more data about learners' conceptual development become available, new and effective strategies would be designed to cater for their needs. It is also hoped that the approach used in this study, especially the inclusion of a controversial topic – water pollution, and the findings would stimulate further studies in the area in attempting to eradicate the problem relating to water and water shortages.

5.3 IMPLICATIONS FOR CURRICULAR AND INSTRUCTIONAL PRACTICES

Looking at the data provided in chapter four, one could see that the learners had made a significant attempt to improve their conceptual understanding of water pollution. Contrary to expectation, they participated actively in the ABI. Although the learners' lively discussions and participation led to a noisier classroom, it was certainly much better than having a dull lesson. This is corroborated by the results (cited in chapter four) of the focus group interview of which the following excerpts are representative:

Teacher: Do you think argumentation based instruction is lively and interesting?

Learner 4: Definitely, almost everyone comes alive and is contributing to the lesson.

Learner 6: It could be a bit noisy at times.

Teacher: Is the noise a problem?

Learner 4: No, It's better than just listening to a tedious lesson.

Teacher: What aspect(s) of the argumentation based instruction did you enjoy or disliked.

Learner 2: My voice is heard in the group and my opinion valued.

Learner 3: The group members helped each other and that causes a sense of belonging.

Learner 5: Some members try to dominate the discussion.

Learner 3: That did not stop me from contributing.

Teacher: Is argumentation based instruction not too time consuming.

Learner 1: No, it is much better than just taking down notes all the time.

Learner 6: In a normal lesson we are not engaging enough.

Learner 2: Teachers do all the talking [Learner 2 added].

Teacher: Do you think argumentation based instruction helped you to understand science better.

Learner 5: It has changed my attitude towards science, science is not dead….maybe I can become a scientist one day.

Learner 4: What I like about argumentation is that you get a chance to reason. The emphasis is not only on providing right or wrong answers.

The above dialogue indicates that learners found the lecture method boring and not as interesting as ABI. The new approach seemed to motivate their classroom participation than would have been the case in the chalk-and talk approach. In terms of TAP and CAT, certain statements such as: “It’s better than just listening to a tedious lesson.”; “My voice is heard in the group and my opinion valued.”; “The group members helped each other and that causes a sense of belonging.”; “Some members try to dominate the discussion.” “That did not stop me from contributing.”; “It has changed my attitude towards science, science is not dead….maybe I can become a scientist one day”; “What I like about argumentation is that you get a chance to reason. The emphasis is not only on providing right or wrong answers”; are indicative of the positive value that the learners associated with ABI.

From the foregoing, it is safe to say that the learners involved in this study enjoyed ABI more than regular traditional instruction used by most teachers. The learners’ statements above as well as those reported in chapter four are in agreement with some of the critical outcomes listed in the new South African science curriculum in terms of encouraging critical process skills, maintaining a responsible attitude towards one’s environment, applying knowledge to solve problems, communicating ideas in an effective manner; making one’s view heard etc. The goal of a learner-centered environment where learners were free to express their views without feeling intimidated accord with the goal of the new curriculum. The opportunity provided by ABI has certainly boosted the overall morale of these learners. A classroom environment where learners are able to participate actively in a dialogue, where their opinions are valued and where they do not fear being ridiculed by their classmates their fears for science are likely to diminish.

Although both the E group and C group were exposed to similar expository science/IKS water pollution lessons, it became evident that an environment of discourse enhanced E group’s conceptions and understanding of the threat associated with water pollution. E group learners argued their ideas and they were encouraged to supply the necessary grounds for their claims. The use of argumentation can lead to the enhancement of learners’ conceptual understanding of science (Osborne, Erduran & Simon, 2004b). I agree with researchers that it is however not easy to ascertain the components (warrants, backings and qualifiers) of TAP (Kelly, Drucker, & Chen, 1998) and it was consequently expressed as grounds. Argumentation based instruction can help to transform the current dull classroom situation into one where a dialogical space is created in order for learners to participate actively and contribute to the learning process.

The findings of this study suggest that there is a need for teachers to consider using a combination of instructional strategies (including ABI) in their instructional practice. Also, the results of this study suggest that traditional expository method of instruction is not as effective as the alternative method in which ABI plays a significant role in helping learners understand water pollution. At the beginning of this study the learners had a poor understanding of water pollution and associated concepts. They lacked the necessary motivation for their studies in science. However, in view of the outcomes of this study, it is apposite to suggest that the instructional approach adopted in the study could serve as a useful means to motivate them in developing a positive attitude towards their studies. As their achievement improves as a result of their conceptual understanding, they might become more confident to find their study a meaningful learning experience (e.g. see Horton et al., 1993).

A plethora of studies have highlighted the importance of discourse in the acquisition of scientific knowledge (Boulter & Gilbert, 1995; Pontecorvo 1987; Schwarz, Neuman, Gil, & Ilya, 2003). This study found that the use of ABI enhanced the learners' understanding of water pollution. The potential of this instructional tool for enhancing learners' understanding of other science concepts is worthy of further consideration.

The use of ABI by teachers could help them interrogate learners' prior knowledge and to seek for ways to make necessary adjustment in their own understanding of a given phenomenon. The process whereby learners seek for a meaningful integration or incorporating the new conceptual understanding into their overall cognitive structure is what Ogunniyi (1995, 2002, 2004) calls contiguity learning or what Aikenhead & Jegede (1999) call smooth border crossing and/or secured collateral learning process.

In teaching any concept the teacher should not only consider the learners' prior knowledge of the concept in question but should also integrate what is taught in class (science) to their everyday lives. This will enable the learners to know that science is not only what is taught in class but a part of their everyday experiences. If learners are made aware of this, their attitude towards science as a subject might improve and consequently, their performance might also improve.

The inclusion of relevant controversial issues, like water pollution, pesticides and the like that are affecting the learners' lives could also be used to arouse their interest in the lesson. Although this approach in some cases may be problematic, particularly for learners from traditional societies who are not used to open formal confrontation or argumentation. There is also the danger of shifting the learners' focus from the real scientific concepts to social issues. However, this approach should be introduced into the lesson in such a way that they form part of the class discussion.

The integration of the everyday science in teaching should not only end in class but should be accommodated in the test and examinations. The emphasis of the newly revised Curriculum 2005 (or simply, the new curriculum) particularly Learning Outcome 3 (LO3) expects learners to develop and be able "to demonstrate an understanding of the interrelationships between science and technology, society and the environment" (Department of Education, 2002, p.10).

However, in the spirit of constructivism and current debates about water scarcity, water borne diseases, genetic engineering, etc., the inclusion of socio-scientific issues or the application of science to social issues seems long overdue.

5.3.1 Water pollution in South Africa

South Africa is semi-arid country therefore every effort is needed to preserve available water resources. The problem of water pollution has negatively impacted on these resources. A growing population particularly in urban areas places a greater demand on potable water. The need to minimize water pollution is regulated by the National Water Act of South Africa (Act 36 of 1998). The act defines water pollution as 'alteration of the physical, chemical or biological properties of a water resource' (Pegram, et al, 2001: p7). Water pollution of the already limited water supply affect all of us differently viz. through health, which impacts education, economy, ecology and recreation. This is a very controversial issue that I used to gain learners participation in argumentation based lessons. Various questions, such as "what are the sources of pollutants?"; "what are the causes of water pollution?"; "who is responsible for cleaning up?" were used to prompt small group discussions. Normally learners are very passive, but these E learners became active participants and it was rather difficult to "control" them. Everyone got involved in the ensuing discussions. In spite of some limitations alluded to earlier argumentation based instruction offers benefits to the science/IKS that would otherwise not attainable. Learners related the science in the classroom to the practices at home and traversed the social cultural borders with relative ease. They held equipollent views about science and IKS which is in agreement with earlier studies (e.g. Aikenhead & Jegede, 1999; Ogunniyi & Hewson, 2008; Ogunniyi & Ogawa, 2008).

5.4 RECOMMENDATIONS

This study has pointed to the important role argumentation has to play in achieving the curricular objectives of the DOE, that is the integration of science and IKS. Narrowing the vast gap between school-based science and home based science (also known as IKS) is indeed within the reach of teachers and learners. In light of this case study it is hoped that researchers in the field will be able to draw from the experiences gained.

5.5 CONCLUSION

From the experiences gained it is of essence that to implement the goals of the new curriculum effectively, teachers will have to be trained on how to integrate science and IKS. Argumentation, as an alternative strategy, with its various elements of claims and justifications cannot simply be used teachers will have to discard the old method of chalk and talk.

In this study, the learners' conceptions of water pollution were examined. After the study learners showed more positive attitudes towards science. The majority of the learners seemed to have made some progress in their conceptual development as a result of their exposure to ABI. It is hoped that the implementation of ABI to a larger group of learners and for a much longer period would provide a strategy for allaying the fears that learners have about science.

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Appendix A:

Letter of permission to conduct research, 2010

7 Glad Avenue
Kuilsriver
7580

1 February 2010

The Principal:
Excel Secondary School
Kings Road
Kuilsriver

Dear Sir

Re: Field work for Masters in Education thesis

My name is Ruben Magerman, a science educator and currently studying for an M.Ed at the University of Western Cape. As part of my studies, I am required to do research and submit a mini-thesis. This letter serves to ask for your permission to do my research at your school.

My research involves finding out the effects of an argumentation-based instruction on grade 10 learners' understanding of the causes of pollution at a river site.

The completion of this study will not only be beneficial to me, but to the teaching fraternity as well, in that I will have added to the pool of knowledge about the use of argumentation based instruction in reaching the goals of curriculum 2005.

I hope that your management team and School Governing Body will see value in this research and grant me the permission.

Yours in education
Ruben Clive Magerman

Appendix B
Water Pollution Achievement Test (WPAT)

Instrument 1: gr 10

Water pollution questionnaire

Name	
Gender	
Career choice	
Home language	
Age	

Question 1
Water is essential for everything on our planet to grow and prosper. Although we as humans recognize this fact, we disregard it by polluting our rivers, lakes, and oceans.
Estimates suggest that nearly 1.5 billion people lack safe drinking water and that at least 5 million deaths per year can be attributed to waterborne diseases. With over 70 percent of the planet covered by oceans, people have long acted as if these very bodies of water could serve as a limitless dumping ground for wastes.

no fishing

River A

1.1 Consider the picture and list the possible causes of water pollution in river A.

1.2 Why is fishing not allowed?

1.3 How can a river near you be kept clean as illustrated by river B?

River B

1.3.2 Identify the differences between rivers A and B.

1.4 There are two different ways in which water pollution occurs, namely point source and non-point source pollution.
Explain the difference between the two (give examples).

1.5 Many causes of pollution including sewage and fertilizers contain nutrients such as nitrates and phosphates. These nutrients cause dense plant life (see fig 1).


fig 1 (narrowed stream)

1.6 What are the implications of dense plant life to aquatic life? Explain your answer.

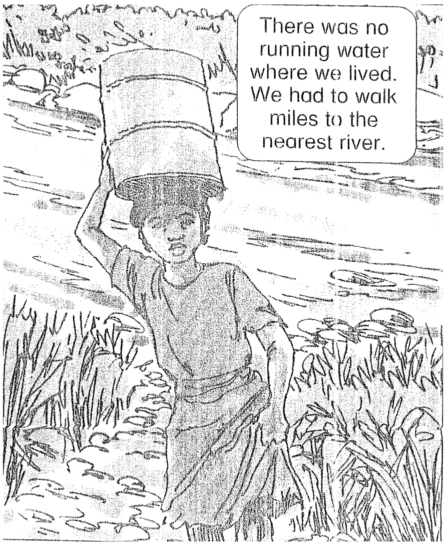
1.7 In addition to innocent organisms dying off, our drinking water has become greatly affected as is our ability to use water for recreational purposes (see river A). In order to combat water pollution, we must understand the problems and become part of the solution. Suggest a few possible solutions to water pollution.

1.8 Do you think household chemicals cause water pollution? Yes/no. Then provide reason(s) to support your answer.

1.9 Who should be responsible for the eradication/control of water pollution?

Question 3

Mrs. Mpondo lives in a rural (countryside) community. The water that her family drinks is collected from a local river. Her children have been complaining about stomach cramps and diarrhea.



3.1 What do you think is/are the cause(s) of them feeling sick?

3.2 How will you purify the water in question 3.1. Name four steps in the process.

.

3.3 What diseases can you get if you drink the untreated water?

3.4 Many people assume that "clean" river water is safe. Do you agree? Give reason(s) for your answer.

Question 4

You have checked the water quality and found many pathogens (an agent that causes disease e.g. bacteria or virus) in a local river.

Tributary of river (fig 2)

Eutrophic conditions, Hartbees River, South Africa
Credit: National Eutrophication Monitoring Programme

Explain to the community forum:

4.1 What are the possible causes of the pathogens?

4.2 How hazardous it is.

4.3 How can the pathogens be minimized?

Appendix C:

Focus group interview

Learner interview schedule

1. Have you received instruction on water pollution in previous years and in what grade(s)?
2. What is water pollution?
3. Can you give an example of a site where the water has been polluted?
4. How did you come to know about it? (News, locally, article etc.)
5. Who/What caused the water pollution.
6. Can polluted water be cleaned?
7. How would you clean it?
8. Whose responsibility is it to keep water resources clean?
9. Should people/companies/farmers i.e. the perpetrators be fined, for polluting the water resources?
10. Do you think enough emphasis is placed on keeping water resources clean?
11. Were the group discussions/ argumentation beneficial?
12. Did you get an opportunity to raise your viewpoints? Was the discussions dominated by anyone?
13. What aspect(s) of the argumentation-based instruction did you enjoy or disliked.
14. Do you think argumentation-based instruction should be used in a science classroom?

Appendix D:

Students' Perception of Argumentation based instruction

Please tick the relevant box according to your opinion, **give a brief explanation for your choice.**

(1) Argumentation creates an opportunity to express oneself.

AGREE		DISAGREE	

(2) My opinion is valued in an argumentation lesson.

AGREE		DISAGREE	

(3) Argumentation based instruction is lively, interesting and interactive.

AGREE		DISAGREE	

(4) I learned a lot from interacting with other learners in my group or other groups.

AGREE		DISAGREE	

(5) The teacher is not in charge, but directs/facilitates argumentation.

AGREE		DISAGREE	

(6) The way the lessons were presented was interesting and it helped me to understand the importance of environmental issues better.

AGREE		DISAGREE	

(7) Argumentation based instruction is a better instructional method than the lecture method.

AGREE		DISAGREE	

Appendix E:

Lesson plan exemplar for E group with ABI

Topic	Learning Outcomes	Instructional strategies	Materials needed (LTSM)
Week 1-3	LO: 1 - 3	Argumentation & Discursive Approach	
Lesson 1: Introduction to Water pollution. Scientific & IKS-based explanations (covered 2 x 50 mins. periods)	Learners should be able to : appreciate 1) the importance of water to all forms of life 2) Africa as a dry continent; Global warming 3) The causes of water pollution 4) The effects of polluted water	• Introduction: Show learners a short video (15 minutes) • Assign learners to groups. Individual task (20 mins.) Each learner completes task. • Learners discuss the elements of water pollution in the groups • Brainstorming and arguing (using the TAP and CAT elements about the causes of water pollution • Learners must gather information about water/water pollution from their parents/elders (the causes of water pollution) • How water was preserved or kept clean in the past	Movie (dvd)/advert clip Media player TV/monitor internet

		• Visit websites – dept of water affairs – data on availability of water- the severity of water pollution in SA	

Topic	Learning Outcomes	Instructional strategies	Materials needed
Lesson 2: Design: Poster on Water pollution. Give Scientific & IKS-based explanations (2 periods)	Learners should be able to : appreciate 1) the importance of visual presentation to illustrate their position 2) The scientific & IKS explanation for water pollution and the preservation of water	• Learners share the gathered info in their groups • Make claims and construct supporting evidence about the causes of water pollution • Teacher recaps the TAP by outlining a good argumentation process • Use both science and IKS explanations for water pollution and possible solutions to the problem • Brainstorming and arguing (using the TAP and CAT elements about the causes of water pollution • Learners design posters to illustrate their stances	Newspaper clips Colour Pens Pritt Clay Plastic bags Various pollutants (grass; bottles; cans; used oil etc.

		• Could make models to represent a crying river	

Topic	Learning Outcomes	Instructional strategies	Materials needed
Lesson 3: Presentation: Water pollution. Scientific & IKS-based explanations. (2 periods)	Learners should be able to : appreciate 1) argumentation as instructional tool to facilitate teaching and learning.	• Learners present their arguments (using the TAP and CAT elements about the causes of water pollution • Discussion on science and IKS based beliefs/practices	Designed charts/models

Topic	Learning Outcomes	Instructional strategies	Materials needed
Lesson 4: Reflection Water pollution. Scientific & IKS-based explanations	Learners should be able to : appreciate 1) the importance of water to all forms of life 2) Africa as a dry continent; Global warming 3) The causes of water pollution 4) The effects of polluted water	• Teacher instructs groups to reflect on the processes they followed to create their arguments or rebuttals. • Group members each receive a rating scale with which to evaluate the contribution of their fellow group members	Rating scale

Topic	Learning Outcomes	Instructional strategies	Materials needed
Lesson 5: Consolidation of the concepts of water pollution. Scientific & IKS-based explanations	Learners should be able to : appreciate 1) the importance of water to all forms of life 2) Africa as a dry continent; Global warming 3) The causes of water pollution 4) The effects of polluted water	• Learners read a written text that deals with some aspects of water pollution and then answer some questions based upon the text	Copies of the text and questions