

**The effect of an argumentation-based instructional
approach on Grade 3 learners' understanding of
river pollution**

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To God be the glory great things he has done.

DECLARATION

I declare that The effect of an argumentation-based approach on Grade 3 learners' understanding of river pollution is my own work, that it has not been submitted for any degree or examination in any other university, and that all sources I have used or quoted have been indicated and acknowledged by complete references.

LORRAINE PHILANDER

Signed: _____ May 2012

ABSTRACT

The research reported in this paper involves the use of dialogical argumentation in scientific context with 7-9 year olds as part of teaching and learning in primary classrooms. To develop an understanding of scientific concepts, four suitable collaborative activities on river pollution were used as a stimulus to effectively engage learners in scientific reasoning and use evidence for decision-making through cognitive harmonization. The research, involved four groups of five children each. Data were collected through analysis of children's Water Pollution Questionnaire (WPQ), classroom observation, documentation of field notes, conversations and focus group interviews.

The study found that all groups were able to engage in the activities to some extent, but that good quality argumentation develops when children are familiar with working in this manner. This study sought to investigate the opportunities, possibilities and challenges associated with a dialogical argumentation teaching and learning approach in a primary school science class. A mapping technique was used to analyze the children's discussions and identify the quality of their different "levels" of argument.

This study confirmed that an argumentation based instruction was an effective way of enhancing learners' understanding of river pollution. The learners' listening skills improved tremendously and they were actively involved during discussions and provided claims with valid grounds or reasons. They were also very enthusiastic and challenged each other's claims during these argumentation lessons, but most of all was the enjoyment that was visible on their young faces. Further research needs to be carried out over a longer period to determine the effectiveness of an argumentation based instruction.

ABBREVIATIONS

CAT	Contiguity Argumentation Theory
DAIM	Dialogical Argumentation Instructional Model
SAIL	Science Argumentation Introductory Lesson
SKIPS	Science and Indigenous Knowledge Systems Project
TAP	Toulmin's Argumentation Pattern
WPQ	Water Pollution Questionnaire
IK	Indigenous Knowledge
EE	Environmental Education
Q	Question
L	Learner
AL	Argumentation Level
OBE	Outcomes Based Education
ABQ	Argumentation Based Question
SSI	Social Scientific Issues

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CHAPTER 1

INTRODUCTION TO THE STUDY

Key words

Contiguity Argumentation Theory

Toulmin's Argumentation Pattern

Cognitive harmonization

Conceptions

Dialogical argumentation Instructional Model (DAIM)

Environmental education

Grade 3 learners

Indigenous knowledge Systems

Pollutants

River pollution

1.1 Introduction

According to Le Grange (2002) the greatest discoveries of the twentieth century lie perhaps not in the realms of science, medicine and technology but in the emerging awareness that we inhabit a planet with finite resources. Clark (1991) claims that the actions of people aggravated by self-centeredness, is the result of constant exploitation of the earth's limited resources causing serious environmental problems which affect the earth's sustainability. Human's incorrect attitude towards the environment have become an alarming threat to the earth and have caused a crisis in the environment (Loubser, 1996). According to Dreyer (1996) the only solution to ensure the survival of humankind and the earth is to in still a change of attitude in humans towards the environment.

The aim of environmental education is to produce citizens equipped with environmental literacy. Through environmental education learners can be taught on how to maintain a healthy relationship with their surroundings especially the rivers in their neighbourhood. (Roth, C.E., 1992: Roth, R.E., 1970: Stapp, 1969; UNESCO, 1980). Although scientific knowledge is not always necessary for environmentally responsible behaviour, but knowledge about the environment has positive effects.

Therefore, a common purpose of science education and environmental education is to educate students to be responsible citizens (Volk, 1984). Environmental awareness has been built into the new South African curriculum for all grades to promote environmental consciousness and sustainability issues (Revised National Curriculum Statement, 2002).

Schools play an important role in the development of children's positive attitudes towards the environment, therefore it is essential that they need to be exposed to environmental literacy from a young age, in order to help them develop an appropriate understanding and perception about preserving the environment (Chu et al. 2007). Environmental education should not only be limited to formal education, but should sustain a lifelong activity.

To address environmental concerns and problems learners can apply their scientific knowledge and skills and become increasingly aware of these problems which will enable them to analyze these and find possible solutions (Arms, 1999). With the dawn of a new democracy in South Africa the need for environmental education became a necessity. This was to bring to light and "rectify the socially unjust conservation laws of the apartheid regime" (Department of Education 2001 b). The land of the minority, which constituted the lion share, was protected by these laws, whereas the majority were deprived in terms of access to natural resources and thus, were disproportionately affected by the dreadful environmental conditions.

As a result of the apartheid legacy, not enough emphasis is being put on environmental education in schools situated in the poverty stricken communities in South Africa. Factors believed to be contributing to this problem is unemployment resulting in poverty, overcrowded classrooms, overloading of the curriculum, poor assessment, enormous administration duties of teachers, lack of resources, environmental illiteracy, as well as the fact that many educators were not fully equipped to teach the curriculum effectively. These schools are floundering, whereas the former Model C schools meant for the whites are flourishing because of being better resourced. (Christie, 1999). How do I as a teacher do justice to a child when he comes to school, tired and hungry?

How do I talk about such a seemingly esoteric matter as environmental conservation? Parents of these poor learners are more concerned with putting food on the table than to care about environmental literacy even though it is a matter that can affect their lives. In communities where the majority lives in make-shift shacks with no toilet facilities how does one persuade members of such communities not to use the streams near them as toilet facilities?

It is therefore not a wonder why many of the rivers running through these informal settlements are polluted? With the spirited effort that government is making to redress the ills of the past particularly with respect to the education system, what role should science education play?

Science education should not only develop critical thinking among learners but also environmental awareness as well. (Habermas, 1972).As a result of scientific and technological development, urbanization and industrialization the sustainability of life on our planet is under threat. Human exploitation of the environment is manifold and complex. However, it is only the actions of people that can ensure that all future generations (i.e. all life forms) derive benefit from our environment. Science education should play a role in bringing these realities to learners who will become our future scientists. Also science education can motivate learners to take action towards improving and conserving water in their environment.

1.2 Background

According to Schreuder (1995) the majority of the environmental problems in South Africa are related to the educational crisis caused by the previous apartheid policies of the South African government. Education resources were not equally distributed and only benefited the minority of the population, whereas the majority received poor education. This resulted in environmental illiteracy, lack of environmental sensitivity and over-exploitation of natural resources.

With the adoption of South Africa's final constitution, human rights and social responsibilities have been linked to environmental issues. The 1995 White Paper on Education saw the need for environmental education processes that involve an active approach to learning. (Department of Education 2001b:3-7).Environmental problems are a global phenomenon. The various UN conferences on redressing environmental abuse have remained inconclusive because the industrial nations have not heeded such warnings and the signs such as global warming, green house effects caused by gaseous emission into the atmosphere, floods, desertification and other disastrous consequences caused by human rapacious attitude towards the environment in search for more energy for consumerist purposes.

The quality of a stream or river is often a good indication of the way of life within a community through which it flows. It is an indicator of the socio-economic conditions and environmental awareness and attitude of its users.

Everything that happens in a catchment area is reflected in the quality of the water that flows through it, because the results of human activity and lifestyle ultimately end up in rivers, through runoff. A river catchment consists of all the land, from mountain to sea shore, that is drained by a single river and its streams. All life in the water is dependent on the interaction within the river itself and in the surrounding catchment. These processes can either maintain a healthy ecosystem or disrupt ecological processes and degrade the water supply (The Waterwheel, May/June Vol. 7. No 3 2008).

Environmental problems and risks are faced by all countries of the world as a consequence of modern life-styles (mainly in developed countries) and poor living conditions (mainly in developing countries). Although the Department of Water and Forestry claims that South Africa's drinking water is safe, it has pointed out that lack of capacity and slack maintenance have caused health risks and pollution in some ways. South Africa could face a water crisis soon if development and pollution were not checked. Water pollution is mainly the cause of immense industrialization, urbanization and the planet's expanding population. Fears about the safety of water follows reports that several participants in the Dusk Canoe Marathon in South Africa contracted stomach aches and other ailments from ingesting Escherichia-Coli infested water from the Tupelo River.

Radioactive pollutants in the Wonder Boom Spruit west of Johannesburg had sparked warnings to farmers not to allow their livestock to consume water from the spruit or to use water for irrigations (Sunday Argus, Feb. 17 2008). There was also a public outcry about the state of the Vaal River when thousands of fish died. According to the National Water Resource Strategy a total of 62% of our water is used for irrigation, while domestic and urban use accounts for about 27%. Mining, large industries and power generation accounts for 8% (Sunday Argus, Feb. 17 2008). Environmental problems and risks are faced by all countries of the world as a consequence of modern life-styles (mainly in developed countries) and poor living conditions (mainly in developing countries).

Although the Department of Water and Forestry claims that South Africa's drinking water is safe, it has pointed out that lack of capacity and slack maintenance have caused health risks and pollution in some ways. Water quality of rivers and streams may differ depending on the geology, morphology, vegetation and land use in the catchments area. Industries, agriculture and urban settlements produce nutrients and toxic substances such as organic and inorganic pollutants and other chemicals including heavy metals.

Water pollutants in rivers occurs when the substances, which degrade the water quality of rivers enter the waterway and change their natural properties (The Waterwheel, Sept/Oct. 2008).

1.3 Motivation for the study

Various factors motivated this particular study. However, the most important factors are discussed under the following sections.

1.3.1 Science and Indigenous Knowledge Systems (SIKSP) project

I was motivated to undertake this study after attending Ogunniyi's (2008 - 2011) seminars and workshops of the Science and Indigenous Knowledge Systems Project (SIKSP) at the University of the Western Cape (UWC). The SIKSP is a huge and labour –intensive project which aims at helping science teachers in South Africa to integrate science with IKS in their classrooms so as to help learners see the relevance of the science they learn at school with the indigenous knowledge held in their socio-cultural environment. My interest was further stimulated by the SIKSP, seeing that it assists Master's and Doctorate students to gain an understanding about how Dialogical Argumentation instruction could help them implement the new curriculum demanding the integration of science and the indigenous knowledge prevalent in learners' socio-cultural environment.

1.3.2 Argumentation in the Foundation Phase

My teaching experience range from Grade 1-7 where most of my years has been spent in the Foundation Phase. Several studies done on argumentation had been with High school learners (e.g. Eskin, 2008; Kelly et al. 1998; Maloney, Simon, 2006). In fact, only a few of these studies had been done in South Africa. I was therefore inspired when I came across studies done among primary school learners (e.g. Keogh, Naylor, Downing, 2003; Samarapungavan et al. 2007).The findings of these studies convinced me that even young children from the age 4-9 are capable of arguing in a scientific context. Argumentation instruction has been found to enhance learners' understanding of various concepts in science and to overcome their misconceptions in science.

As they argue, listen and discuss with others, learners are able to correct their own misconceptions. Argumentation has also been found to facilitate dialogues especially when dealing with socio-scientific issues (e.g. Erduran, et al, 2004; Jimenez-Aleixandre, Rodriquez & Duschl, 2000; Maloney & Simon, 2006). The next challenge was to find a theoretical framework on which to base my study.

Like a building design, a theoretical framework provides the necessary outline and procedure to follow when conducting a piece of research work. Without such a framework, the researcher would be working by trial and error.

1.4 Theoretical framework

A review of the literature shows the several theoretical frameworks that have been proposed to describe how learners acquire new knowledge, skills, attitudes and change their worldviews about one subject matter or the other after listening to what other learners say. Since my study was concerned with finding out grade three learners understanding about water and water pollution, a socio-scientific issue, I found among others the Toulmin's (1958) Argumentation pattern (TAP) and Ogunniyi's (1997) Contiguity Argumentation Theory (CAT) to be the most appropriate for this study. TAP is concerned with scientific arguments based on the inductive-deductive method of argument while CAT is based on the cognitive shifts that tend to occur when a person holding an indigenous knowledge or belief encounters science and makes sense of the two systems of thought.

It is a well known fact that the scientific way of interpreting human experience is distinctly different from the indigenous way of interpreting human experience (Ogunniyi, 2007a). I decided on both theories seeing that it addresses different aspects of human knowledge. The two frameworks seem to provide an overview of how science educators can use and assess the nature and quality of scientific argument in particular and emphasize the linkage between each framework (Sampson & Clark 2008). More details about the theoretical framework underpinning the study would be presented in the next chapter.

1.5 Statement of the problem

In South Africa fresh water is decreasing in quality because of an increase in pollution and the destruction of river catchments, caused by urbanisation, deforestation, damming of rivers, destruction of wetlands, industry, mining, agriculture, energy use and accidental water pollution.

As the human population increases, there is an increase in pollution and catchment destruction. Water pollution is a major problem in the global context. It is the leading worldwide cause of deaths and diseases, and it accounts for the deaths of more than 14,000 people daily (<http://www.randwater.co.za>). The state of our river ecosystems are generally deteriorating with effluent pollution continuing to grow (The Waterwheel, Vol. 6(5), Sept/Oct. 2007).

The demand on South Africa's scarce water supply (including rivers, wetlands, estuaries and groundwater is increasing. We need to ensure that sufficient quantity and quality water are available for human and ecological needs (The Waterwheel, Jan./Feb. 2009). Water pollution has been the focus of widespread public interest and it seems to be increasing (Sunday Argus, Feb. 17 2008) The Municipal council maintains that the rise in pollution levels over the last ten years can be attributed to rapid urbanization, an increase in the number of informal settlements without adequate services, and aging infrastructure (Supplement to the Cape Argus, Wednesday March 25 2009).

Sustainable aquatic ecosystems depend on the availability of water of adequate quantity and quality. The global fresh water resources are under increasing pressure. The City of Cape Town has detected gradual increases in Escherichia-Coli (E-Coli) and Faecal counts present in the Metropolis fourteen rivers and ten wetlands. Escherichia-Coli (E-Coli) has made the Black river in Athlone unsuitable for recreational use. This had been caused by the run-off from informal settlements along the river. These micro-organisms are key factors of pure water quality. Almost every one of the rivers of Cape Town runs through informal settlements. While the majority of South Africans have access to fresh drinking water from a tap rather than a river, stream or spring, the pollution of water resources still affects us directly.

According to Dr. Stanley Liphadzi (Conference Chair, Water Research Commission & Department of Water Affairs & Forestry Report, 2009), International Conference on Implementing Environmental Water Allocations) people think that the protection of the environment is the main responsibility of the government, ecologists and conservationists. He asserts that all South African citizens have a vital role to play in looking after and protecting our water and plants. People and the natural environment cannot be alienated from each other. The dreadful conditions of our country's water resources through pollution and over-allocation do not only influence our aquatic ecosystems, it could also hurt our finances.

The report also emphasizes that the more chemicals, metals and other toxins are thrown in our rivers, the more expensive treatment is necessary to clean the water for human consumption. This results in water tariffs being increased for the same amount of water being used.

It is of utmost importance that the huge demands on our aquatic resources are balanced fairly. To improve a strong economy with social standards in this country a healthy aquatic ecosystem is needed. All sectors need to grasp and know the important linkage between the water in the environment and in our taps.

The major problem facing the African continent is the lack of adequate drinking water supplies and sanitation facilities. Millions of Africans still do not have access to safe drinking water. Since the sixties we have witnessed a growing awareness of the effects of human exploitation of the environment, drinking water supplies and sanitation facilities. Water related diseases and illnesses are responsible for the deaths of most of the five million children under five years old who die annually in Africa (Switzer, 1994).

Pollution can be harmful to living organisms or lead to all forms of environmental disasters causing ill-health or poor productivity of lands (Botkin and Keller, 1995). Insufficient supplies of water and sanitation disproportionately affect women, children and the poor. More than 2.7 billion people will face water shortages of freshwater by 2025 if the world keeps using water at today's rates. In 1992 the Earth' Summit in Rio de Janeiro set goals for sustainable development, including guaranteeing every individual access to clean water and sanitation (Nagel, 2003). Le Quesme (2009) of the Water Wheel Forum (WWF) claims that implementing policies is not enough to foresee that aquatic environments are looked after and that there is enough water to sustain these environments. Existing policies in South Africa requires that the Reserve has to be determined before any license may be issued.

According to Stephan Mallory from Water for Africa "ecological water requirements are not easy to determine since they depend not only on the large number of natural components present in nature and forming an integral part of the ecology, but also the wide range of hydrological conditions experienced from zero to extreme floods (The Water Wheel, May/June 2009). South Africa is a semi-arid country, thus we need to take care of the little water that is available.

1.6 Purpose of the study

In agreement with the aim of the study was to determine the effect of a dialogical argumentation instructional model on grade three learners' understanding of how water and water pollution affect human welfare. More specifically the study attempted to determine:

- (1) The effectiveness of an Dialogical Argumentation Instructional Model (DAIM) in enhancing grade three learners understanding of, and awareness about some of the causes of water pollution.
- (2) The effectiveness of DAIM in enhancing grade three learners' understanding of the scientific and Indigenous methods of keeping water safe for human consumption.

1.7 Research questions

In pursuance of the aims of the study, answers were sought to the following questions

- What conceptions of the causes and effects of water pollution do grade three learners hold?
- How effective is an argumentation-based instruction in enhancing the learners' understanding of water pollution?
- Are the learners' understanding of water pollution related to their age, gender and social economic background?

1.8 Hypotheses

The following hypotheses with regard to the questions above were posited for testing.

- Grade three learners do not hold valid conceptions of the causes and effects of water pollution.
- An argumentation-based instruction will not have significantly affect on the learners' conceptions of the causes and effects of water pollution.
- Learners' conceptions of water pollution are not related to their gender, age and social economic background.

1.9 Significance of the study

Numerous studies have been done in trying to emphasize the importance of teaching and learning of environmental education in schools. Chu et al (2007) points out that environmental education in schools needs to undergo a dramatic change because it is totally failing in improving young children's environmental literacy. It is hoped that the findings of this study will (1) contribute to studies directed at enhancing grade three learners' understanding of, and awareness about causes of river pollution. (2) help, to determine alternative conceptions that the learners hold on water pollution (3) expose learners to a variety of teaching strategies and materials such as fieldtrips, storybooks about the environment and mass media, such as newspapers, magazines, and television programmes that can be effective for young children. (4) Be informative in enlightening and motivating teachers to use different instructional teaching methods including argumentation and inquiry-based approaches in increasing learners understanding of, and awareness of causes of river pollution in their area.

1.10 Limitations of the study

This study had the following limitations

It was limited to only one primary school and hence the result of the study cannot be generalized to other schools. The instruments used to collect the data i.e. the Water Pollution Questionnaire (WPQ), classroom observation and the focus group interviews were conducted in English. Since most of the learners' Home Language is Afrikaans and their Language of teaching and learning is English, language barriers sometimes might occur and is thus considered a limitation regardless of the fact that the language of the instrument was simplified to suit their ability. Each question had sub-sections, which did not required straight forward answers as they had to provide reasons where possible.

To prevent contamination of any kind the two research groups (E and C) had to complete one question in a specific timeframe depending on its length. All learners in both classes had to start and finish the questionnaire on precisely the same time. This was done in the middle session after first interval. Under no circumstances were learners allowed to complete the rest of a question the following day.

This was very time constraining because I had to fit into the time schedule of the educator who mastered the control group. Time was only made available after she completed her days lessons as well as her assessment tasks.

1.11 Delimitations

Water pollution is a wide topic and numerous alternative conceptions have been identified using a range of methods. The study focused only on the effectiveness of a Dialogical Argumentation Instructional Model (DAIM) on learners' conceptions of the causes and effects of water pollution, An attempt was made to explore the indigenous methods of keeping water safe for drinking.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter explores the theoretical and practical aspects of the study. The theoretical consideration focuses on contextual issues in which argumentation instruction has been explored in the extant literature. This was to situate the study in the context of what scholars in the area of argumentation instruction have said or experienced. It also explores the theoretical framework for the study. The practical consideration deals with actual studies specifically concerned with the effectiveness or otherwise of argumentation in enhancing learners' understanding the concept of water pollution.

2.2 Theoretical Considerations

By means of the increased global awareness of the harmful impact of scientific, technological and industrial actions on the environment and numerous examples of sustainable practices among diverse indigenous peoples, the new South African science curriculum statement has called on science teachers to integrate school science with Indigenous Knowledge Systems (IKS). The call to integrating science with IKS are namely that such systems reflect the wisdom and values that people living in Southern Africa have acquired over centuries. The Science and IKS Project (SIKSP) project is a challenge attempt to use argumentation-based workshops to equip science teachers to implement a science–IKS curriculum in their classroom (Ogunniyi and Hewson 2008). Cobern & Loving (2001) suggest that IKS be barred from school science whereas Corsiglia and Snively (2001) disagree since IKS provide valid knowledge that western science has not yet mastered.

The current environmental crisis is attributed due to western science and technology and that the hazardous conditions need to be re-evaluated in sincere honesty as it is threatening the life of mankind. They argued further that indigenous people's contributions have been devalued for monetary and political purposes.

It was against this background that certain scholars have begun to pay more attention as to how IKS can be used to improve the bio-physical environment in non-western societies (Hewson, 1988; Hewson & Hewson, 1988; Odora-Hoppers, 2002; Ogunniyi, 1988, 2004). The current environmental crisis is attributed due to western science and technology and that the hazardous conditions need to be re-evaluated in sincere honesty as it is threatening the life of mankind. They argued further that indigenous people's contributions have been devalued for monetary and political purposes.

The policy statement of the new South African curriculum did not specify how teachers and learners could explore the relevance of IK to school science. Nevertheless, a plethora of studies have shown that a curriculum that promotes discussion, argumentation, dialogue, and reflection is of more value for promoting understanding of the Nature of Science (NOS), IKS, or the two systems of thought (e.g., Abd-Ehl_Khalick, 2004, 2005; Aikenhead, 1997; Driver, Newton, & Osborne, 2000; Ebenezer, 1996; Erduran, 2006; Erduran, Simon, & Osborne, 2004; Garrouette, 1999; Kelly & Bazerman, 2003; Kelly & Takoa, 2002; Lawson, 2004; Michie & Linkson, 2005; Niaz, Aguilera, Maza, & Lliendo, 2002; Nichol & Robinson, 2000; Ogunniyi, 2004, 2006a, b; Osborne, Erduran, & Simon, 2004; Simon et al., 2006).

In response to this call to integrate science and IK this study focused on how Dialogical Argumentation Instructional Model (DAIM) could enhance grade three learners' understanding of water, and water pollution as well as how science and IK could be integrated to accomplish this objective. However, before exploring the theoretical consideration more closely, it is apposite to examine and to ground the innovative instructional approach in this study in the context of such theoretical considerations. Of the several learning theories that have been applied in science education social constructivism seems most appropriate for this study in that it focuses on how new knowledge could be made relevant to the existing knowledge that a learner possesses i.e. the knowledge the learner has acquired from his/her formal and informal settings. Dialogical argumentation instruction, which framed the study was based considered learning as involving individual as well as group dialogues and or related activities with the overall goal to attain as much as possible cognitive harmonization.

2.3 Social constructivism

According to Lambert et al (1995) constructivism is the principal foundation of learning where persons integrate their past practices, beliefs and culture as well as their ways of thinking in the learning process, thus influencing how they relate and understand new ideas and actions. Also social constructivism thoughts constructed by Vygotsky (1978) highlights the significance of society, culture, and language (Vygotsky, 1978; Lemke, 2001). According to this viewpoint, knowledge is socially created and that learning takes place in a social and cultural perspective. As growing diversity within our schools are increasing, it is critical that learning in science classes needs to emancipate from a traditional to a social constructivist approach in order to set the tone based on extended dialogical argumentation framework within our schools.

Brooks and Brooks (1993) claims that group work promotes learner interaction, fosters cooperative learning, within the group and offer prospects within the various science curriculum. Also that a major change for the learners are to construct their own understanding through hands on activities. I am in total agreement, but however wants to argue that dialogical argumentation takes group work to an advance level in the science class based on the fact that the learners first have an internal dialogue, followed by an ultra dialogue which lead to group consensus. What highlights the argumentation process is the fact that individuals as well as the groups need to provide evidence for whatever claims they make.

2.4 Prior-conceptions

It is crucial that teachers must be aware of student's prior knowledge of science concepts. The students' background must be taken into consideration when teachers plan instructions as well as the materials American Association for the Advancement of Science [AAAS], 1990). Studies have shown that students enter science classes with thoughts about the natural world that do not line up with accepted scientific beliefs (Wandersee, Mintzes, & Novak, 1994). The importance of learners' prior knowledge before teaching a new concept is vital. Mintzes and Wandersee (1998: 81) point out that, "The single most important factor influencing learning is what the learner already knows." Carey (1986) also states that scientific understanding cannot be achieved without grasping the intensity and tenacity of the student's prior knowledge.

Therefore, science teachers need to decide on science content and design curricula that will interest and enhance student's knowledge, understanding, abilities and experiences (National Research Council [NRC], 1996). Knowledge is socially constructed and based on the learner's existing knowledge and experiences, for that reason it is significant for a teacher to be conscious of student's prior science concepts (Von Glaserfeld, 1993). It is expected of teachers to be aware of and understand common naïve concepts in science for given grade levels, as well as the cultural and experiential background of the students and the effects these have on learning" (NRC, 1996:31). The students' background must be taken into consideration when teachers plan instructions as well as the materials.

Studies over the past 20 years (Wandersee, Mintzes, & Novak, 1994) have confirmed that students' prior knowledge on numerous science concepts have been influenced by previous experiences, textbooks, teachers' explanations or everyday language. A great deal of research has identified students' preconceptions in different science concepts and where most of it was done outside the daily classroom environment. Yet, any experienced teacher would know that valuable knowledge can come from learners if, they are given the opportunity to express themselves in the classroom. Ideas that the teacher never ever thought of can turn into a valuable class discussion resulting in other learners also contributing.

2.5 Importance of listening in argumentation

According to Maloney & Simon, (2006) listening is not merely a matter of being silent when another person speaks, it brings about a response to what is being said. I indeed agree with the above claim. In experience, young learners need to be taught on how to apply their listening skills. Teachers cannot just suppose that learners are listening attentively if they are quiet. Teaching learners to listen attentively is a process that needs to be mastered. Without this skill, young learners will find it difficult to respond to open-ended questions, to reason critically, agree or disagree and come up with evidence during conversations. Some educators must also learn to listen to their learners and not just think that learners are defying their authority nor must they feel offended if learners' question them on academic grounds. It is the latter that some teachers find very difficult.

Therefore, it is of utmost importance that educators should adapt and change their methodologies during teaching. In my opinion, learners need to be taught how to listen so that argumentation can be applied effectively. I have a special session each day for fifteen minutes, called “Your young opinion counts”. This has been implemented with great success in my class. Five learners are selected each day where they tell anything of importance to the rest of the class. It is then required from the rest of the class to listen carefully, and ask questions thereafter.

Within these small group discussions, learners feel that their voice are being heard. Whether they agree or disagree but also to reach consensus at the end of the day in their group. It is also during these sessions that I have discovered the value of these young learners’ argumentative skills. These sessions usually motivate the quiet learners to participate actively in these discussions. It is required when children work collaboratively in a group that they need to listen to each other in order to formulate their own ideas. When children listen to each other, they articulate their own ideas. (Newton et al., 1999).

2.6 Importance of language in argumentation

According to (Vygotsky, 1978) language plays a foremost role in learning because it involves talk and more precise argumentation. Language in the science classroom in recent years (Mortimer & Scott, 2003; Sutton ,1992) has increased our awareness of how teachers’ use of language influence the pedagogy of science. Goodwin and Goodwin (1987) emphasize in “Children’s Arguing” linguistic features of children’s argument. They claim that “arguing provides children with a rich arena for the development of profanely in language, syntax, and social organization (p.200). I agree with the Goodwin’s claim bearing in mind that during the current study, I noticed how the learners linguistic ability improved tremendously.

The more they were exposed to argumentation, the better they started to argue with each other, and the more fluently and clearly they engaged on a high level argumentation talk. In addition they also included the new vocabulary taught to them while arguing with each other. On top of this, the learners developed a sense of self confidence. An important aspect of language in science education is the use of argument, which is involved in generating and justifying claims to knowledge (Dushl, 1999) and in clarifying, persuading and resolving differences (Andrews et al, 1993). Argument and discussion do not feature prominently in science teaching in the UK (Newton et al, 1999). They state further that debate and discussion take up less than 1% of teaching most of the time.

Yet, a case can be made for promoting argument in the science classroom because it provides a great opportunity for learners to express their views, clear their doubts and modify their ideas as they become more knowledgeable of a subject matter. Arguments play an important role in scientific discourses. A cursory look at the history of science would reveal how scientists argued about one subject matter or the other e.g. nature of atoms, genes, planets, blood circulatory system and a variety of natural phenomena. However, arguments are not limited to the science they are frequently used among indigenous communities to relate one experience or the other. Arguments are usually rendered in different versions in the oral histories and myths of indigenous peoples.

It usually ensue whenever people attempt to convince each other about one thing or the other (Ogunniyi, 2008). It is worth noting that despite its importance, arguments are not encouraged in the South African science classrooms. Likewise, arguments are hardly encountered in the science textbooks or classroom discourses even in controversial subjects like evolution from the learners' point of view. So far, most of the research studies that have been carried out, have been done at the secondary school level. The reason for conducting this study at the primary school level was premised on the belief that argumentation is not limited by age. It is a rational process carried out by all human beings, which becomes refined as one grows up in life. Other related reasons for teaching argumentation at the primary school level include:

1. The researcher is a primary school teacher and is well aware that learners do engage in all forms of argumentation on a daily basis.
2. It is the right of a child for his/her voice to be heard in the classroom.
3. The earlier learners are familiar with the correct methods of argumentation the better for their intellectual development.
4. Learning argumentation from the primary school level could enhance the way learners reason and justify their claims.

2.7 Argumentation as an instructional tool

Argumentation is not new, and for many years religion, politics and law have relied on it as a means to express a viewpoint or maintain a stance (Erduran, Ardac & Yakmaci-Guzel, 2006). Teaching argumentation in science has been suggested in many a study in science education (e.g. Ogunniyi, 2004, 2006, 2007; Ogunniyi and Hewson, 2008; Osborne et al, 2004, It has become a subject of increased interest especially in relation to classroom discourses (e.g., Driver et al, 2000; Ebenezer, 1996; Erduran et al, 2004; Ogunniyi, 2004, 2006, 2007 a & b; Simon et al, 2006; Zohar & Nemet, 2002). Several of these studies have indicated the value of dialogical argumentation as a leading instructional approach to develop teachers' and learners' scientific knowledge in science education as well as increasing their awareness about scientific inquire (Ogunniyi, 2004).

Since argumentation is vital in producing, evaluating, and advancing scientific knowledge, its process is of utmost importance. To participate meaningfully in an argument certain conditions must be met. These include the ability to follow and be willing to submit to the force of a better argument. The need to recognize one another as equal and reasonable arguers. No matter what we think or know, the opportunity to argue with other people may help us to learn new things. But whatever the case, the worldview we may want to convince others about in an argument may after all be relative i.e. what is valid for one may not be so to the other. Each stance a person takes depends on the underlying assumptions. The merits or demerits of an argument is, an unavoidable rhetorical tool for participating in a significance discussion (Ogunniyi 2007a). The main aim of an argumentation is to inform and shed light on thoughts in order to reach a decision.

According to Ratcliff & Grace (cited by Maloney and Simon, 2006:1817), "The extent to which children learn how to engage in debate and use evidence in science is important for future decision-making, particularly in the context of socio-scientific issues." My teaching experience supports this view in the sense that young children love socio-scientific topics and when such topics are introduced into the classroom debates cannot be easily prevented. It seems that arguments and debates tend to deepen their scientific knowledge on the particular topic in question. One will be surprised to find out what learners already know about socio-scientific issues. When they feel that their prior knowledge is valued they argue freely.

This results in an attitudinal change to the extent that even learners who do not usually talk tend to come out of a shell so to speak on the subject matter being debated. Maloney & Simon (2006) state further that if the ability arises in developing argumentation, children need to learn how to reason, to assess options and to justify claims through evidence. Argumentation is dialogic in the sense that it is done individually, thereafter co-constructed in the group, considering the claims of other group members. Children can argue naturally, but to argue scientifically, needs definite guidance. Therefore, teachers need to plan the activities to such an extent so that the learners can argue even if they have limited science knowledge. The more they are exposed to argumentation, the more they are able to reason scientifically and excel in it.

Kuhn (1991) on the other hand also agrees that argumentation is obtained through continuous practice by hands of appropriate activities. Other researches (Hogan & Maglienti 2001; Zoar & Nemet, 2002) have also agreed on the same conclusions. Maloney & Simon (2006) explored the behaviour of 10-11 years-old groups of children arguing and using evidence in decision-making in science. It involved four different collaborative activities. A mapping technique was developed to evaluate the discussions and identify different argumentation levels. The results show that appropriate collaborative activities that focus on the discussion of evidence can be developed to exercise children's ability to argue effectively when making decisions as well as determining the level of their argumentation.

Argumentation plays a major role in the resolutions of questions, issues, and disputes (Siegel, 1995) and can be done in schools through activities where children reason about problems in different contexts (Jimenez-Alexander & Pereiro-Munaz, 2002, 2005; Zeidler et al., 2003). On the other hand, Carsaro (2003) did a study in three pre-schools, namely California, Indiana, and in Italy. He discover that children are skilled at forming arguments and engaging in argumentation. Nonetheless argumentation is seen as a negative practice at the middle or upper middle class, pre-school, and adults are quick to not be in favour of it. He disagrees and states that argumentation can be seen as a fundamental role in children's peer culture, supplying societal peer groups, rising and strengthening friendship ties, the confirming of cultural values, and the individual development and display of self. In developing decision-making skills, children need to learn how to reason to evaluate alternatives, and to weigh up evidence completely; in other words, to develop the ability to engage in argumentation (Maloney & Simon, 2006)

The knowledge of scientific facts is not all that matters in Science Education. Value must be put on the process of critical reasoning and argument that will enable children to understand science (Driver, Leach, Millar, & Scott, 1996; Driver, Newton, & Osborne, 2000; Millar & Osborne, 1998). Not enough justice is being done to teaching and learning of argumentation in science as such.

If argumentation is applied through appropriate tasks and pedagogical methodologies, it will promote epistemic, cognitive and social goals as well as children's conceptual understanding of science (Osborne, Erduran, & Simon, 2004). According to Kelly et al (1998) several researches have experienced problems in using TAP to determine the construction and components of an argument, whereas Erduran et al. 2004; Jimenez-Alexander & Pereiro-Munoz, (2005) claim that other researcher have found it valuable as a logical device to relate to classroom dialogue.

Simon et al. (2006) pointed out that the ability to understand and follow arguments of a scientific nature is a critical part in scientific literacy in its basic sense. Ratcliffe & Grace (2003) emphasize the importance of argumentation skills to be taught to young children as early as possible as group intervention for older children will have a limited impact. Children are eager to participate in-group discussions. If teachers confront learners with activities that make them think rather than take note verbatim they are likely to seek for evidence to justify their claims. Keogh, Naylor and Downing (2003) investigated the use of argumentation with concept cartoons in science education with 7-9 year olds. The results showed that the children were able to co-construct arguments which enhanced their overall understanding of the task they were confronted with.

2.8 Toulmin's Argumentation Pattern (TAP)

There has been an increased awareness in determining the effectiveness of argumentation in enhancing teachers' and students understanding of the Nature of Science. (e.g., Ogunniyi 2004, 2006, 2007 a & b; Ogunniyi & Hewson, 2008; Erduran et al, 2004; Naylor, Downing, Keogh, 2001, Simon et al, 2006). Ogunniyi & Hewson, (2008) indicate the fact that numerous studies have shown the significance of dialogic argumentation as a valuable instrument for teachers' and learners' conceptual understanding as well as making them aware of the tentative and material-discursive nature of science construction.

The degree to which children learn to engage in discussion and use evidence in science is important for future decision-making, especially in the context of socio-scientific issues (Ratcliffe & Grace, 2003). Toulmin's (1958) Argumentation Pattern (TAP) has been used by several researchers to improve educators' and learners' understanding of the Nature of Science (e.g. Kelly & Bazerman, 2003; Kelly & Takao, 2002; Osborne et al, 2004; Erduran et al, 2004; Jimenez-Aleixandre et al, 2000). According to Ogunniyi & Hewson (2008:161)

TAP consists of such elements as:

1. Claim-The statement that is asserted or declared as the truth of a subject matter e.g. the liquid in the glass is water. However, we would not be certain of how truthful this statement is until we have carried a scientific test. In other words, we need more data.
2. Data-The evidence gathered from our observational or experimental testing or the reason we use to confirm the truth of the assertion.
3. Warrants-The justification which links the claim with the evidence.
4. Backing- The underlying assumptions on which the claim is based.
5. Qualifiers- The conditions binding the claim.
6. Rebuttals-The statement that contradict the claim (Simon et al, 2006).

Some scholars e.g. Erduran et al, (2004) have modified Toulmin's framework to determine students' use of rebuttals in-group work. Due to the complex nature of TAP and the overlap of its constituent elements, they have combined data, warrants and backings into "grounds". A good argument in their opinion is based on two assumptions: (1) the grounds, which include (data, warrants and backings) to verify the claim, and (2) arguments with rebuttals are of better quality than those without. Ogunniyi (2009) has further modified TAP as espoused by Erduran et al (2004). See Table 2.1

Ogunniyi (2004) Levels of Toulmin's Argumentation Pattern

Quality	Characteristics of an argumentation course
Level 0	Non – oppositional
Level 1	Argument involves a simple claim versus counterclaim with no grounds or rebuttals
Level 2	Argument involves claims or counterclaims with grounds but no rebuttals.
Level 3	Argument involves claims or counterclaims with grounds but only a single rebuttal challenging the claim.
Level 4	Argument involves multiple rebuttals challenging the claim but no rebuttal challenging the grounds (data, warrants and backing) supporting the claim.
Level 5	Argument involves multiple rebuttals and at least one rebuttal challenging the grounds.
Level 6	Argument involves multiple rebuttals challenging the claim and /or grounds.

Table 2 1 Source: Ogunniyi (2004) Levels of Toulmin's Argumentation Pattern

Prior studies have shown that school teaching spent limited time on developing skills which are of utmost importance for learners to construct scientific arguments (Maloney & Simon, 2006). This statement resonates with my own experience. Educators who have not been trained on argumentation will find it immensely difficult to try this approach in class. Schools that are under staffed cannot do justice to the science curriculum because educators who are not qualified to teach science, are teaching it.

Besides, many of them have limited subject matter knowledge to use a dialogical argumentation instruction. According to Andriessen (2006) argumentation in science is not oppositional and aggressive. It is an outline of collaborative debate in which both parties are working together to unravel an issue through common agreement. He further more argues that collaborative argumentation must not be competitive, as this will prevent learning taking place in a systematic way.

Perelman (1979) claims that criticism and justifications are important during argumentation, and that an individual will not be capable to understand an argument correctly if he/she is not certain about what the argument is all about. Kelly et al., (1998) states that several researches have experienced problems in using TAP to determine the construction and components of an argument, whereas Erduran et al. 2004; Jimenez Alexander & Pereiro-Munoz, 2005 claims that other researchers have found it valuable as an logical devise to relate to classroom dialogue.

Simon et al. (2006) points out that the ability to understand and follow arguments of a scientific nature is a critical part in scientific literacy in its basic sense. Erduran et al (2004) claims that argumentation is an effective tool for teaching science. Kuhn (1992, 1993a) state that science taught through argumentation enhances scientific thinking in young children. However, useful as TAP is in analyzing claims, counterclaims and rebuttals made by people, it does not address arguments that attempt to describe human experience and socio-cultural issues and beliefs not easily amenable to formal deductive-inductive logic.

Often, the values that people associate with certain cultural beliefs and symbols, which in certain respects are legitimate and meaningful, may lack strict empirical validity. Also, as learners move from their traditional communities into the science classroom, they are likely to encounter conflicts of ideas and values which in turn may predispose them to develop positive or negative attitudes towards school science. To get along with school science they have to shift from one cognitive state to another. The reverse is probably true as they return from school to their home environment. It is in this context that the Contiguity Argumentation (CAT) seems to be more appropriate than TAP.

2.9 The Contiguity Argumentation Theory

The Contiguity Argumentation learning theory is embedded in the Platonic and Aristotelian contiguity notion which claims that one or two states of mind tend to connect, with or evoke each other to create a most favourable cognitive state. Ogunniyi & Hewson (2008:161) state that “The Contiguity Argumentation Theory (CAT) on the other hand deals with both logical or scientifically valid arguments as well as non-logical metaphysical discourses embraced by IKS” According to Ogunniyi (2007a & b) there are five categories which CAT recognizes into which conceptions can move within a learner’s mind when dealing with conflicting worldviews of science and IKS or between learners involved in dialogues on one issue or the other.

He argues further that these five cognitive categories exist in a dynamic state of flux. The cognitive states are:

- Dominant – a powerful idea that is most adaptable to a given context.
- Suppressed - in another context the same dominant cognitive stage can become suppressed by, or assimilated into another more adaptable cognitive state.
- Assimilated – A conception becomes assimilated into one that is more adaptable.
- Emergent and - An emergent cognitive stage occurs when an individual has no previous knowledge of a given phenomenon as would be the case with many scientific concepts and theories e.g. atoms,
- Equipollent - An equipollent mental state occurs when two competing ideas or worldviews tend to co-exist in his/her mind without necessarily resulting in a conflict e.g. creation and evolution theory.

2.10 Misconceptions

Misconceptions are formed when students develop their own interpretations of explanations in school or early in their school years (Wandersee et al., 1994; Cardack, 2009). If not corrected misconceptions will continue for years and cause barriers for them in understanding scientific concepts. Preparing effective lessons play an important role in teaching these conceptions (O-Saki & Samiroden, 1990).

2.11 Environmental Education

The environmental crisis we are in, is not merely based on our physical existence, but also on our spiritual existence namely our understanding of what we are and how we should relate to the world around us (Bonnet, 2007:719). Hungerford and Volk (1990: 1532) argues that environmentally responsible behaviour can be achieved only when learners have thorough understanding of environmental issues. I am in total agreement with Hungerford and Volk. The more knowledgeable children are about the environment, the more responsible and sensitive they will react towards it. Chawla (1998) claimed that effective teaching can enhance learners' awareness in learning about the environment and promote full participation in protecting the environment.

According to Oztaz and Kalipi (2009) environmental education enables children to become socially responsible human beings. It helps them to make careful decisions about the future of their environment. It also deals with a wide range of environmental experiences, methods and processes. Teaching environmental education is not an easy task. It should not just cover pure ecology education, but also include the citizenship responsibilities and the problems that are sourced from other interdisciplinary factors. It is teachers responsibility to facilitate environmental issues.

Teaching children to value and understand the environment and its related problems not only contributes to building socially responsible individuals, but can also help such individuals to develop wholesome attitudes towards the environment (Young and La Flotte, 2009). Children are seen as an essential linkage for environmental communication in today's society and going "green" is a synopsis of becoming more aware of environmental problems that challenge the human race (Mohapatra and Bhadauria, 2009). Inspiring environmental awareness in future generations requires educators who are equipped and skilful.

Bonnet (2007:707) argues that the present environmental predicament does not only provide an exciting opportunity to re-focus education to one of the issues about human relationship to nature, but also requires the exploration of this issue for its long term resolution. Environment Education (EE) is a vital element of a child's education to assist him/her develop sufficient environmental awareness and adopt positive attitudes and behaviour in order to be an environmentally knowledgeable person. Narrowing the gap between teacher training and environmental sustainability is a tough challenge. Although many studies have been done to reconstruct alternative conceptions of water pollution, only a few of these have targeted the primary school level. The Education Department is committed to implement environmental awareness in the school curriculum. Regardless of this, environmental awareness in communities remain low. Communities are still not yet knowledgeable about environmental issues affecting their lives.

2.12 Practical Considerations

A study done by Oztaz and Kalipi (2009) was aimed at detecting basic environmental education knowledge of 248 Turkish prospective teachers. A questionnaire was administered during the first month of their final academic year. The findings of that research indicated that the prospective teachers had very limited environmental knowledge.

The study also showed that the subjects did not possess the underlying ecological and environmental concepts related to it. Goodwin & Goodwin, 1987 have debunked the notion that boys and girls argue differently. Kuhn (1992) also states that she found no sex or age difference in the ability to employ skills necessary to engage in argumentation. She however claims that an individual's educational achievement will determine the result to develop these ability.

In itself argumentation is all about reasoning and critical thinking of informal logic (Jimenez-Aleixandre, Rodriguez & Duschl, 2000). Maloney & Simon (2006:1820) indicates that "reasoning, evaluating, and justifying are the skills employed in resolving arguments, and for children it can be developed through decision-making activities that are sources of evidence." In addition they also claim that prior studies have shown that school teaching has tended to spend limited time on developing argumentation skills among learners. Simon et al (2006) investigated teaching of argumentation in secondary schools. The results indicated that in developing the ability to understand and implement argumentation, teachers need to pay close attention to learners' ways of viewing things.

Starvidou and Marinopoulos (2001) studied primary learners' conceptions of water and air pollution in Greek. They found that that the learners knew very little about the causes and sources of water and air pollution and its harmful effects on humans in a questionnaire given to 11-12 year-old students. The results showed that the students realized how acid rain is formed and that air pollutants and waste are materials that can interact chemically with other substances when they get into the atmosphere or water. As pointed out by Stavridou and Marinopoulos (2001) the majority of the learners involved in their study regarded the phenomenon of water pollution as a local event without seeing the global picture.

Shodh, Samiksha, aur Mulyanka (2009) explored a study on environmental pollution among grade six and seven students in India. A structured interview was done with 30 students from a government school who were willing to participate in the study and who had to come from the same educational and home environment. The findings indicated that the majority of the students had a sound understanding of air pollution. The grade six students' knew that smoke from factories, vehicles, and houses pollutes the air. 93% of the students partially knew about water pollution. The majority of the students knew that pesticides pollute water and only 20% knew that fertilizers used to increase the production of food grains also pollute water. Most of the grade six students were aware that air pollution has an effect on the lungs.

Most of the grade seven students partially understood that polluted water cause diseases. Nearly all of the students partially had an understanding on how to control water and soil pollution. Some however, held the misconception that to avoid pollution solid waste should be dumped deep in the ground to prevent the upper soil from being polluted. In other words they were not aware that underground pollutants could still contaminate underground water.

A study conducted by Chu et al (2007) investigated Korean children environmental literacy levels affecting their environmental literacy. An instrument measuring knowledge, attitude ,behaviour and skills were given to grade three students. The findings indicated that the correlation between attitude and behaviour is much higher than between knowledge and behaviour. The study also reveals that over 90% of the children had positive attitudes regarding clean air and water and that they were aware of air and water pollution, seeing that these stories have been integrated in their curriculum. The study also revealed that gender, parents' school background, and the sources where the children got their information affect all the categories of environmental literacy tested.

Mohapatra and Bhandauria's (2009) findings of a study to determine Indian secondary level grade 10 students' alternative conceptions of water pollution showed a number of misconceptions held by the students e.g. many of the students did not see any relationship between sewage, pesticides and soil erosion and water pollution. A study done by Yurttas and Sulun (2010) aimed at determining the nature of the conceptions that grade eight learners held about the most important environmental problems in Turkey and the world. An interview consisting of multiple choice questions and closed-ended questions was administered to the learners. According to the results air pollution was seen as the most serious problem followed by water pollution. Global warming, unplanned urbanization and waste were furthermore viewed as the most important environmental problems in Turkey while global warming, thinning of the ozone layer and acid rain are considered as the most important environmental problems in the world.

Tikka et al. (2000) have argued that an educational milieu is not sufficient in developing positive attitudes of students, other than their involvement in environmental activities as well as their individual awareness are also fundamental aspects in shaping environmental attitudes. Malkus and Musser (1997) imply that once students achieved the basic understanding and positive attitudes regarding environmental issues, students will be more concerned about the environment.

It seems that the more knowledgeable children are with regard to environmental issues, the more they are likely to respect it. A study by Fazio & Zanna (1981) has revealed that environmental education should not be to comprehend the chemical-biological causes of stream pollution, but the awareness in society which look upon the polluted stream as a problem. They further mentioned that the problem lies in society and not in the environment.

They argue further that children are giving scientific knowledge on environmental concerns, as well as issuing them with empirical encounter with nature, but they are not provided with the social, cultural, economic and political knowledge and encounters.

2.13 Studies Concerned with Integrating Science and IK

The presentation so far has been largely based on school science perspective and yet learners come to school with considerable knowledge about water contributes to environmental stability. Children from rural settings are well aware of how local people take great care to ensure that the waters they drink are free from germs and sources of contamination. The communities observe strict practices to ensure that streams are not contaminated through human activities. Some practice all kinds of taboos to restrict human activities from water bodies. For example, forests around streams are not allowed to be cut down or burnt for farming or domestic uses. Children are not allowed to swim in areas where drinking water is fetched for domestic use. The water brought home are put in large pots and allowed to settle down or boiled before drinking. Studies exploring learners' indigenous knowledge (IK) are very few and widely scattered around the world.

Research in the area is still relatively new. For example, Waldrip and Taylor (1999) interviewed three village elders and 15 high school students in a South Pacific country regarding the relevance of school science to students' future lives. After about a decade of attempts to develop valid notions of the nature of science among prospective secondary science teachers Ogunniyi (1988) came to the conclusion that:

- (1) There is no significant difference between the dualistic worldview held by his subjects from rural and urban centres.
- (2) Both literate and non-literate subjects held similar dualistic worldviews.
- (3) The two systems of thought are not necessarily exclusive of each other, i.e. it is possible for an individual to hold a scientific and indigenous worldview.

(4) The two systems of thought are not always in conflict with each other i.e. most of his subjects saw each system of thought.

(5) The sex, religion, tribe or level of education of the subjects does not have any significant influence on their indigenous worldview.

(6) The scientific worldview may not be able to completely displace the subjects' indigenous worldview.

(7) An exposure to a well-organized history/philosophy of science enhanced his subjects understanding of the nature of science.

Ogunniyi (1995) explored the worldviews of prospective and practising science teachers in Botswana, Indonesia, Japan, Nigeria and the Philippines. They found that the subjects subscribed to both scientific and indigenous worldviews without exhibiting any sign of cognitive dissonance. From his analysis of the nature of science teaching in African schools, and their analysis of curricula developed for the Northern Territory of Australia, Michie and Linkson (1999) indicated that the major challenge in developing curriculum relationships between indigenous knowledge and Western science was the difficulty in finding points of convergence (in terms of approaches taken by the two knowledge systems) between the two distinctly different worldviews.

The findings showed that the enculturation into a Western school view involved (1) an implicit devaluation of the students' indigenous worldviews, which governed their village lifestyles; and (2) that such an enculturation process is of limited viability in relation to traditional values and practices. Manzini (2000) explored ways in which the learning experience of South African black learners could be influenced by a culturally relevant science curriculum. In a series of science lessons based on selected African practices, the learners showed great enthusiasm and appreciation for the IK component of the curriculum.

Ogunniyi (2000) using eight fictitious stories of diverse phenomena examined worldviews held by South African teachers and learners. He found that while the teachers were more inclined to the scientific worldview than their learners both groups still held a dualistic worldview consisting of science and IK. Most studies done on IK or the integration of IK with science in Africa have been done under the auspices of the Science and Indigenous Knowledge Systems Project (SIKSP) located at the University of the Western Cape.

Since its inception in 2004, the focus of SIKSP has been to equip primary and secondary school science teachers with necessary knowledge and skills to integrate science with IK in their classrooms. In a series of studies (e.g. Ogunniyi, 2004, 2005, 2007a & b; Ogunniyi & Hewson, 2008; Ogunniyi & Ogawa, 2008) found that the primary and secondary school teachers exposed to a dialogical argumentation instruction improved, not only their understanding of the nature of science but developed a greater enthusiasm and appreciation for IK as well.

Similarly, the teachers made noticeable perceptual shifts from construing science and IK as polar opposites to considering them as legitimate, compatible and complementary systems of thought. In their review of a study carried out by Hewson and Ogunniyi (2011) Otulaja, et al (2011) that IK and school science do not always have to be merged and made compatible since there are areas of epistemological convergence and divergence. They further suggested that the dialogical relationships of convergent and convergent IK and science should be allowed to co-exist with each other. This conclusion is in agreement with what Gunstone & White (2000) and Ogunniyi (1988, 2007a &b) recommended.

2.14 Conclusion

In this chapter, a brief review has been made of theoretical and practical considerations concerning argumentation as an instructional tool for integrating science and IK. What seems to have emerged from this brief review is that there is still much to know about the nature of science and IK before one can attempt to integrate the two systems of thought together. In other words, the findings in the area are inconclusive and warrant further investigation. It is in the light of this that the effect of dialogical argumentation among grade three learners is being explored with the hope that more insight could arise from such an endeavour.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter describes the overall research design and the methods used in carrying out the present study. The literature review in the previous chapter emphasize the importance of language as stated by Fang (2006:491) to construct knowledge, beliefs, and worldviews in school science which is different from the social language that learners speak daily. The literature review conducted, as well as exploring new ideas, new sources, and different teaching strategies will be the focus point in answering the aims of this research.

This chapter gives a detailed account of the approaches used in the development of the instruments of an argumentation based instruction on learners understanding of water and how to prevent water pollution. Furthermore it will establish the process of validation and reliability. It will also include the research design, the sampling procedure, collection of data, analysis and reporting. This chapter will give account of the learners' responses to the Water Pollution Questionnaire (WPQ). It will report on a small focus group interview conducted with the learners. The interview gives a high level of interaction between the learners and the researcher.

3.2 Research methods

Qualitative and quantitative research methods were used in the study. The reason being was to strike a balance between the two that will make valid contributions to the study. Using both methods gave me the opportunity to assemble a thorough holistic data set at the research being done.

3.3 Pilot study

The research took place over two phases. A pilot study was carried out with a grade two class, age 7-8 years old which took place over ten weeks involving five mixed ability groups of children in the same school. The aim of the pilot study was to try out the various developed instruments and activities related to the research approach. Whether the activities are interesting and relate to children's knowledge.

Also to find out if it stimulated them for discussion and argument (Samarapungavan,1992). This also gave the researcher time to reflect on areas that still needs to be improve for the real study. Furthermore to determine the quality of young learners argument in a socio-scientific context. Also to find ways in how mixed ability groups can reason with ease and come up with valid evidence to justify their claims (Maloney & Simon, 2006).

This was done through observation, field notes, hands on approach activities, an experiment by the four groups, body gestures, audio recording their conversations and interviews. A questionnaire was administered to both the C and E group and answered by the learners. A further aim with the pilot study was to identify and eliminate their initial conceptions on the causes and effects of water pollution. The aim of the Water Pollution Questionnaire (WPQ) and interview in the Pre- test of the E and C group all the learners stated that water pollution refers to papers or dirt being thrown in water.

They were unaware that water can be polluted in various ways and that it is a global and not just a local problem. In three groups there was at least one learner who tried to get the other learners involved in talking. The fourth group however did not get involved in any talk at all. After a while each learner received their individual task to complete. After completing the task it was obvious that they were able to talk a little more freely but did not go into a discussion. There was a major change after the intervention with regard to the group discussions which led to the learners arguing and justifying their claims with evidence. The real study took place the following year with grade three learners.

3.4 Research design

This study is based on a quasi-experimental research design. The two groups involved are intact rather than randomized groups. This constraint is compensated by the fact that participants all studied under real classroom conditions as to minimize the disruption of normal teaching time. Also the design controls for all the rival hypotheses with the exclusion of the effects of testing (see Ogunniyi, 1992:87). Regardless of this, the design was effective for the present study. One class in the school served as the true experimental group (E), and another class served as the true control group (C). The control (C) teacher however used a normal Outcomes Based Education (OBE) instruction whereas the experimental (E) teacher used Ogunniy's (2008) Dialogical Argumentation Method based on Toulmin's (1958) Argumentation Pattern (TAP).

Learners in the E group were exposed to the same instructional model for seven weeks. The E group had 20 learners and C group 18 learners. The experimental group (E) will undergo a pre-test and a post test. The control (C) group will experience the pre-test, normal OBE structured teaching and a post test. The groups were all similar with respect to their chronological age, gender and achievement.

The research design adopted for this study is as follows:

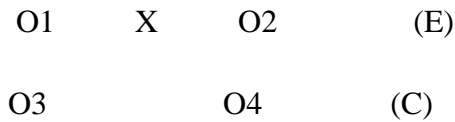


Figure 1: Quasi-experimental control group design

O1 and O2 represent the pre- and post-test for the experimental group (E) whereas O3 and O4 stand for the pre- and post-test for the control group (C). X stands for the treatment, namely the Dialogical Argumentation Instructional Model. The lines indicate that intact rather than randomized groups were used (Ogunniyi, 1992:91). The E group received treatment in the form of Dialogical Argumentation whilst the C group did not. The same concepts covered in the E group were also covered in the C group. Both the experimental and control groups are comparable. This was evident from the mean of pre-test scores.

Seeing that the experimental and control groups are at the same school the possibility that contamination may take place between the two groups and influence the validity of the results may be possible. Most of the questions in the questionnaire are open ended and have subsections. To prevent contamination of any kind I decided in co-operation with the control group's teacher that both groups will only complete two questions a day. Also that they will start on exactly the same time and finish it before break time. This will prevent learners from discussing the questions with each other during break and allow the teacher to go on with her normal teaching time as the questionnaire was completed during assessment time.

3.5 Sampling

The sample consisted of 38 grade three learners from a primary school in Cape Town. The learners who participated in the study were diverse in nature. The medium of instruction at the school is both English and Afrikaans. Only the two English grade three classes were chosen to participate in the study. The learners that participated in the study were heterogeneous. One class was used as the experimental group and the other class was designated as the control group. The ages of the learners varied from 7-9 years. I used the DAIM for the experimental group. The other grade three teacher (Control group) used the normal OBE structured teaching.

Table 3.1 Students involved in the study according to gender, age and language and religion.

Group of students	Experimental Group E (n=20)	Control Group C (n=18)	Total
Gender: Females	9	8	17
Males	11	10	21
Language of instruction:			
English	20	18	38
Home Language:			
English	13	11	24
English & Afrikaans	5	4	9
Xhosa	1	3	4
French	1	0	1
Age: 7 years	3	2	5
8 years	10	10	20
9 years	7	6	13
Religion:			
Christian	17	15	32
Muslim	3	3	6

3.6 Instruments

The study involved three types of instrumentation: An Argumentation-Based Questionnaire (ABQ) in conjunction with a follow up interview and a systematic structured classroom observation involving field notes were the major data sources. These instruments were used to assess the participants ability in engaging in dialogical argumentation and to provide evidence in resolving their arguments.

3.6.1 Development of WPQ

Water pollution is a broad topic and I had to make sure which aspects I wanted to focus on in my instrument. After looking at the environmental concepts of grade three's requirements, I considered and identified the vital concepts that will structure my teaching, to effectively teach the concepts and engage in the activities to be covered in the course. The WPQ consisted of eight questions with related subsections. In seven questions the learners had to provide reasons or grounds for their chosen answer. Five questions presented scenarios. In one question, learners had to agree or disagree with regard to a claim by providing valid evidence.

Providing reasons for their answers was a way to find out if learners were able to reason critically. Focus group interviews were then carried out with eight learners, namely four boys and four girls as to triangulate the data from the questionnaire as well as to get a deeper understanding of the learners' concepts of water pollution. A great attempt was made to ensure that the illustrations in the WPQ was of interest to the learners to ensure that these young learners could relate to names and situations in the questions and identify with the opinions given. I made sure that the children chosen in the illustrations were of similar age as well as the respondents in the research. Both genders were also visible in the illustrations to ensure that it will not have an effect on the learners responses. Lubben and Muller (1995:511). The fact that the characters in the illustration had to be lively was also of great importance. Young children love illustrations and pictures where the characters are doing something.

The questions went through a process of validation to attain a high level of reliability. To attain the face content and construct validity the draft WPQ was presented to a professor, colleagues at seminars who had to comment on the clarity of the instructions, time allocated, the readability, and the comprehensiveness i.e. that the aspects of water and how to prevent water pollution was covered adequately. Furthermore it was given to five experienced Foundation Phase teachers at three different schools who had to rank the questionnaire on a scale from 1 to 5 subjected to Spearman's Rank Difference Correlation Formula which represented the following:

- 5- strongly agree that the question was relevant and clear
- 4- agree that the question was relevant and clear
- 3- not sure that the question was relevant and clear
- 2- disagree that the question is relevant and clear
- 1- strongly disagree that the question is relevant and clear

To ensure that the discrepancies, ambiguities and inconsistencies were not visible in the WPQ items ranked under 3 were eliminated. The reliability of the final version was 0.89 on the Kuder-Richardson 21 scale. In addition the draft instrument was also pilot tested with a grade three class at another school, of the same socio-economic background to establish its validity and reliability. This allowed me to evaluate the instrument with regard to content, and structure. As mentioned earlier, the WPQ was administered to thirty eight grade three learners as a pre-and post test.

3.7 Interviews

3.7.1 Focus group interviews

Lofland and Lofland (1984:12) claim that an interview is “a guided conversation whose goal is to elicit from the interviewee rich, detailed materials that can be used in qualitative analysis”. A focus group interview were then carried out with eight learners, namely four boys and four girls from the main study as such to triangulate the data from the questionnaire as well as to get a deeper understanding of the learners' concepts of water pollution. According to Vulliamy et al., (1990:106) triangulation is the procedure where the findings from one data source is checked with another.

3.7.2 Selection of interviewees

The learners were chosen by their own group members and not by the researcher. Ample time was given to them on deciding which two persons will represent their group in the interview. Some learners spontaneously indicated in their group the availability and willingness to be interviewed. I observed each group closely to see how they selected their representatives. After reaching consensus in their group, they read the names of their representatives for the post-interview.

Altogether eight learners were chosen for the focus group interview. They also had to clarify on what basis they selected their learners. In my opinion it was obvious that they based their selection on group discussions while completing their activities. When I wanted to know how the selections were done in each group, they said without doubt the following:

Transcript

Group 1: L2 “We all chose L3 because she is not shy and can argue very good.”

Group 2: L4 “We wanted to chose only boys but L4 said that it’s not fair and she was angry. She said girls are just as good as boys. So we all chose a boy and a girl in the group for the interview.

Group 4: L3 “We all agreed that L2 can go. He always tells us strange things while we argue that they do in their country and he can talk a lot and he makes us laugh’.

Group 4: L1 “We didn’t chose someone because L2 said that she wanted to do the interview. She said she was the one who argued the most in the group. So we agreed that she can go”.

The analysis of their responses of the WPQ was based on gender, language and eagerness to participate. Girls and boys were equally represented. Sanders and Mokuku (1994) points out that an interview provides English Second Language learners a more effective way to structure their ideas. The interviews were conducted at the beginning of the study and at the end of the study to obtain information on whether or not learners held any alternative ideas after the study.

3.7.3 Constructing the interview

The interview schedule consisted of five questions. These items were directly linked to the questions and items in the WPQ seeing that the interview was to be used to triangulate the findings in the WPQ. The interview was once again given to my co-supervisors and five teachers to give advice. A “trial run” was also done with the interview using grade three learners from another school so that I could identify any behaviour that might influence the experimental result and thus compromising the validity of the study.

3.7.4 Conducting the interviews

Interviews were planned for 30 minutes so that sufficient time could be given to interviewees whose first language is not English ensuring them enough time to comprehend the question and give a response (Sanders & Mokuku, 1994). It however lasted for fifty minutes after the children engaged in sustained dialogical argumentation.

3.7.5 The interview schedule

The interview schedule acted as a guide and was not followed strictly according to the sequence how the questions were drawn up. When the learners ideas probed deeper into the interview questions, more time were provided to answer it. Thus resulting in a good constructed response from them. Gunstone & White (1992: 86) imply that if questions are asked in a rush, learners will feel anxious and will not be able to answer the questions to the best of their ability. He further argues that an interview that involves a concept is a dialogue intended to convey the knowledge that a person has about the concept.

They further points out that from all the types, this kind is the best manner for assessing a person’s insight. At times the learners would argue intensely regarding each other’s responses, each providing grounds for their claims. To be honest, I loved this part of the interview and it was obvious how good they felt knowing that their contributions were valued. I did not get involved in the interview, but at times I would, by commenting on a given response for example, “You raised a good point”. This comment inspired the learners to continue with their discussions as well as to comment on each other’s ideas. They gave well constructed answers and not just single words.

Under no circumstances were the learners directed into giving the answers associated with the interview as Nkopodi & Rutherford (1994) points out i.e “leading the witness” When the learners did not fully grasped the question or their answers were unclear it was important to restructure the question as well as the answer as to get clarity on it. This was to ensure that there was no misunderstanding on behalf of the interviewee or interviewer.

3.7.6 Interview setup

The interview took place in a natural setting as far as possible. It was done in the same class where students were busy during their activities and where they were most comfortable. I had to make the learners at ease because some were quiet anxious when they saw the tape recorder while others were eager to speak. Nkopodi & Rutherford (1994) states that a person whose anxious, will at times just speak because he/she does not want to be seen as an ignorant one. I further more had to reassure them that it is not a test and as far as possible they must not be shy to convey any ideas. I also mentioned to learners that if they know how things were done in the past, or in their own country or village from where they come, it will be quite interesting to share their ideas with the rest of the group because it can be of great value.

3.7.7 Analysis of the interview

The interviews were transcribed and transcripts of each interview were given an identity. Responses were labelled according to the ideas of water and water pollution they seemed to reflecting. This was used to support the findings from the WPQ. The analysis attempts to link both the quantitative and qualitative data that emerge from a range of instruments.

3.7.8 Classroom observations

Classroom observations were done during the learners discussions of an activity. The children were given a series of activities which they first had to do individually and then coincide with further discussions in the group to reach a common agreement. Short detailed notes were written on their non-verbal behaviour during the sessions. A tape-recorder was used to record the discussions in the group and during experiments.

The aim of these observations was to establish learners attitude with respect to water and water pollution. Whether learners had any alternatives about water and water pollution concepts and if so, what kind of alternative conceptions?

It was noticeable during observations that when the children engaged in argument, many undertook a specific role within the argument. This had an effect on the type of argument they were discussing. As they became more engaged with the content their argumentation level raised. This resulted in three or four children leading the argument as such while the others in the group will listen, support, dispute and also encourage the other children to get involved (Naylor, Downing Keogh, 2001). Whether learners had any alternative conceptions of water and water pollution and if so, what kind of alternative conceptions it is.

3.9 Data analysis

The children were observed and video-recorded while discussing their decisions and all conversations between the groups of children were audio-recorded and then fully transcribed. The learners responded positively to all the activities and engaged in focused discussion, signifying alternative viewpoints seen as argumentation. Even though they came up with evidence for a certain point of view the argument was often a dialogical attempt to attain a valid assurance (Naylor. S., Keogh, B., Downing, B. (2001). Analysis of the transcripts used will establish frameworks from Toulmin (1958) which was adapted by Eduran, Simon & Osborne (2004) for determining students rebuttals in group work.

3.10 Pedagogical schema

3.10.1 Teaching strategies

The activities were based on a pedagogical schema of earlier works largely encouraged by (e.g Erduran, Simon & Osborne, 2004; Ogunniyi, 2007a and b) that developed out of a sequence of workshops that has been piloted. The first phase of the pedagogical schema is based on a individual task where the learner had to come to grips with the given problem in making claims and providing grounds for it. The second phase results in dialogical argumentation of small groups, where individual members share their science/IKS phenomena by making claims and providing grounds.

During this discussion members can agree to disagree, come up with counterclaims, grounds to stand on and even rebut. In ending the dialogical discussion, they need to reach agreement within their group. The third phase is a group presentation, where they report their findings on a poster clearly indicating their claims, counterclaims, grounds and even a rebuttal if there's any.

The fourth phase gives the rest of the class the opportunity to question the group doing the presentation and also to add more ideas which the group presenters did not think of.

The fifth phase is a focus group interview where questions are raised to determine their conceptual understanding of both science and IKS. This model allowed learners to actively participate in the activities, and not to be scared when making mistakes.

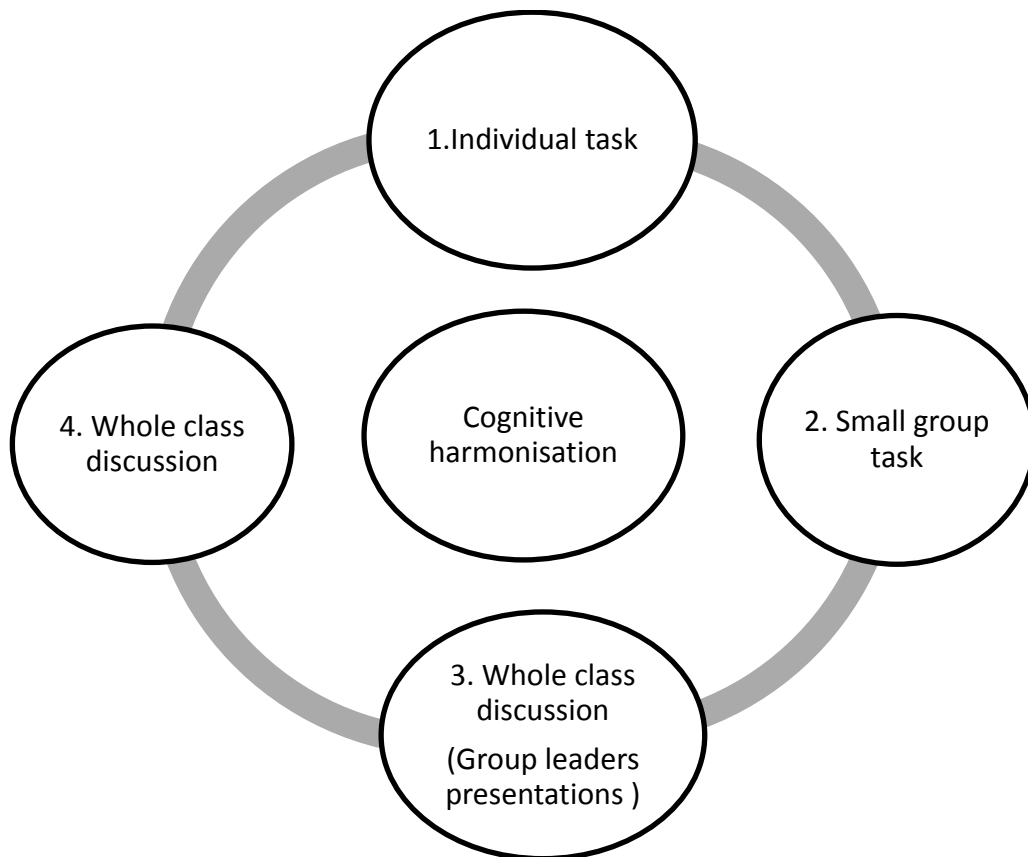


Figure 3 1Pedagogical scheme of argumentation used by the Science and Indigenous Knowledge Systems Project (Ogunniyi, 2009)

3.11 Science Dialogical Argumentation Introductory lesson

Learners will experience difficulty when generating an argument because they are not use to this type of scientific argumentation. Therefore it is vital that the teacher move from group to group interacting with the learners by asking questions and not just provide learners with the answers. Through questioning the learners the teacher will zone deeper into their understanding and enhance their critical reasoning and argumentation skills (Hall & Sampson, 2009).

Phase 1 was a Science Argumentation Introductory lesson (SAIL) which consists of four lessons. This was to prepare the learners in knowing what is a claim, evidence and a counterclaim. It also gave them the opportunity to think ahead so that they could argue much better. This lesson lasted two weeks each consisting of four 60-minutes class periods a week.

The learners' prior knowledge also played a vital role with regard to the timeframe of the SAIL. Learners will experience difficulty when generating an argument because they are not use to this type of scientific argumentation. SAIL was initiated as follows: The learners were organized into three small groups of five and one group of six. Each group was allocated a number.

Straight forward examples were used to get the learners underway. The lesson was intended to offer learners the opportunity to improve their verbal, communication, writing skills as well as their scientific understanding and critical-reasoning skills (Sampson & Grooms 2009). Activities related to the topic were developed to see whether 7-9 year old children could engage in dialogical argumentation in small groups, using evidence to justify their claims (Maloney & Simon 2006).

The activities were developed and given to four groups that were suitable for learners of this age to see if they could apply critical thinking as such. The small groups gave each learners the opportunity to contribute to the discussion and argue with each other. It was a mixed boys and girls group.

3.11.1 Lesson 1:Activity 1

Learners had to brainstorm the word "water" individually and then as a group by drawing up a mind map. Thereafter they had to engage within their peer group for further discussion as to refine their ideas and to reach agreement on their group's mind map. The learners did not find it difficult to write down their own ideas about the word "water" They however found it difficult to share their ideas in the group as they are so use to the fact, that other learners may not see your work. I also had to reassure them that it is not a test. After hearing this they were more comfortable. Subsequently I decided to select a group leader for each group after observing them for quite some time. This was based on the learners' outspokenness to get the whole group underway. Also it was not easy for them to come to an agreement in the group with regard to their ideas.

Some of them just refused bluntly to share their ideas in the group and refused to participate, clutching their mind map tightly against their chest. It took some time to convince these learners that no one will steal their ideas. I urged the group leaders to acknowledge each group member by naming him or her for their ideas during the presentation. This worked well and everybody was happy. At this stage there was no critical reasoning taking place. Learners just had a discussion with regard to the word “water”. They were also urged to speak in full sentences.

It was however surprising to see what they actually knew about the word when I moved around from group to group. To conclude this activity each group had to do a presentation on their mind map. Seeing that it was the learner’s first presentation, I did not involve questioning at this stage, as this might make them anxious and discourage them for the next presentation.

The main aim was to make the learners comfortable during their presentations and praise them for every effort they made. At this stage most of the learners were quite unsure about what to do as this was really something new to them. To stand in front of a class explaining something is not easy. Therefore it was essential, to first develop their confidence as such. The group presentations started off at a snail pace, except for five learners who really was a spark plug to the rest of the class, even if it was by means of a smile and a reassuring nod of the head. This was so heart warming to see the learners surely but slowly getting involve. I was so overwhelmed, by all this. I studied each group’s mind map intensely and highlighted the different ideas they wrote down on the board. This gave me an idea what the learner’s pre-conceptions were with regard to the word water.

The under mentioned mind map is an extract of the above.

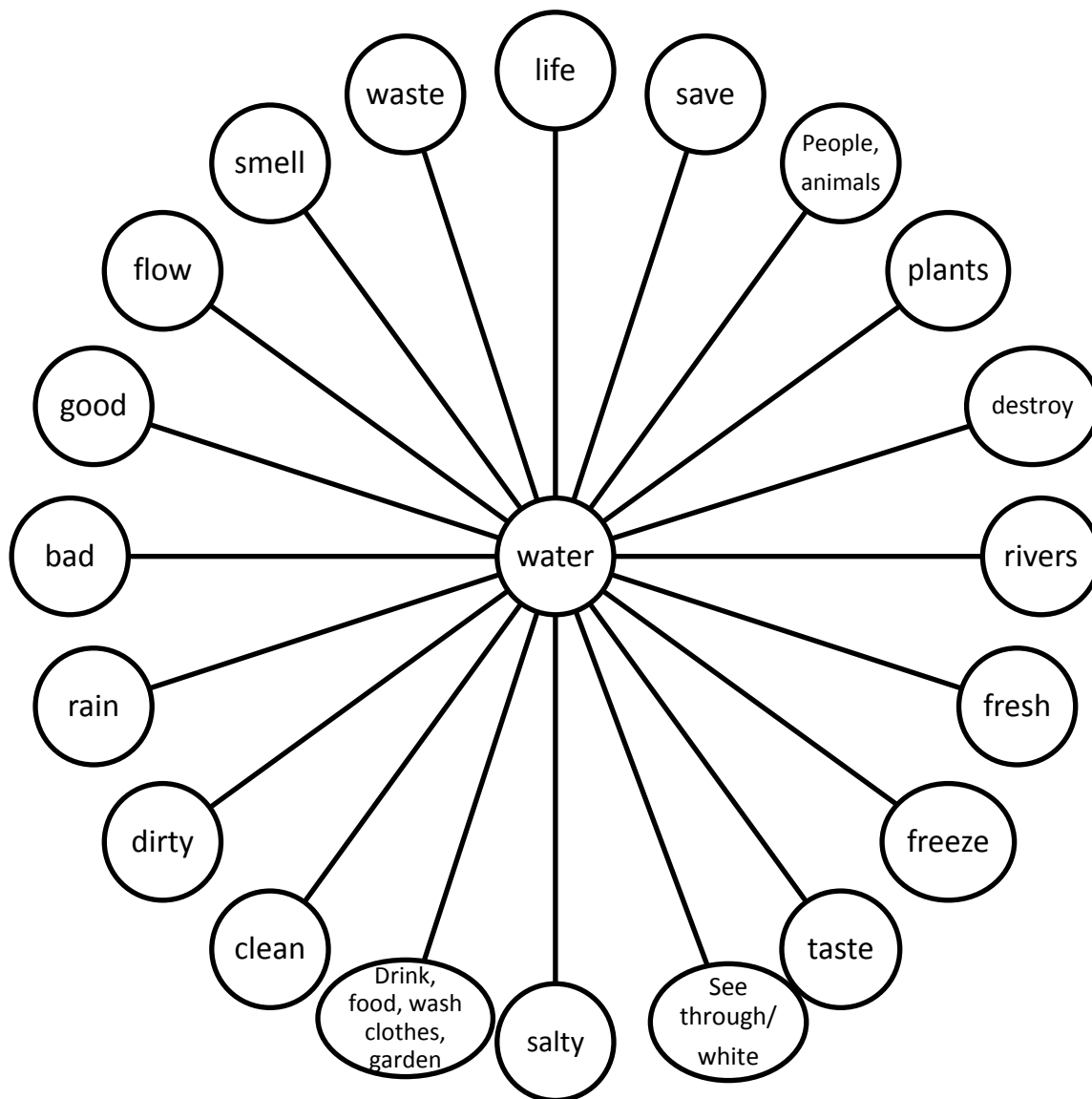


Figure 3 2 Summary of learners’ pre-conceptions on water.

The learners were observed intensely to see how they interacted with each other. The brainstorming was used as an elicitation method to clarify their thinking and impose the need to resolve the cognitive conflict which will reveal in arguments. According to Millar & Murdoch, (2002:29) “Elicitation is the first stage in a process of determining what they (the pupils) want to know and helping them to develop their ideas surely indicates the prior knowledge” learners had of water. From the mind map it is obvious that the learners had prior knowledge on the topic. It was interesting how individual groups came up with different ideas.

I summarized all the groups ideas on their mind maps and then categorized it, which brought me to the conclusion that the following was evident in all the mind maps namely:(1)The importance of water . (2) Uses of water. (3) Water pollution. (4) Saving water.

Questions were asked, to which participants were expected to answer first individually and then in small groups. Finally the small groups' representatives presented their agreed solutions as well as areas where they hold opposing views to the whole group. The overall facilitator then summarized the consensus reached where feasible. Specific examples of the outcomes of these activities are presented in Appendix 3.

3.12 Ethical Consideration

The importance of ethical issues cannot be more emphasized, especially if humans are involved. The following steps were taken to ensure that the study conformed to the ethical standards laid down by the Senate Research Committee of the University of the Western Cape:

- The name of the participating school and the learners will be kept anonymous.
- No information regarding the school or the learners will be disclosed to anyone
- Permission were seek from the school principal and teacher where the study took place.
- Permission was granted based on the fact that it did not interfere with the teaching and learning process. Neither must it also overburden the learners.
- The aim of the study was orally explained to the principal and teacher.
- To prevent the overburdening of the teacher's workload, the teacher and the researcher had a close look at her work schedule to determine where the research topic will fit in and in what term it will take place.
- This made it much easier for the teacher as the research topic was included in the Life Skills Programme.
- The teacher of the control group was reassured that she will still make use of the same teaching approach in her class, whereas I will use a different methodology for the experimental group.

- The learning material was prepared for both groups.
- Learner questionnaires were anonymous.
- All interviews were strictly confidential.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

The emphasis of this section is to: (1) present the overall shift in the learners' conceptual understanding as depicted by mean scores, standard deviations and t-test of the Water Pollution Questionnaire (WPQ) scores; and (2) see whether the learners held any alternative conceptions in the pre-test which were still present at the post-test. The post-test data will focus on the alternative conceptions of the E group and not that of the C group whose alternative conceptions remained basically the same after seven weeks of instruction. (3) to ascertain whether or not differences in gender, age language and social economic background are related to learners' understanding of water pollution.

The Water Pollution Questionnaire (WPQ) was developed and administered to 20 learners in the E group and 18 learners in the C group as a pre-and post test. The WPQ consisted of eight questions with related subsections. In six of the questions, the learners had to provide reasons or explanations for the chosen answer. To be contextual and relevant to the learners' daily experiences, five questions dealt with water pollution scenarios. In one question learners had to agree or disagree with regard to a claim by providing valid evidence. Focus group interviews were then carried out with eight learners, namely four boys and four girls as a way to triangulate the data obtained from the questionnaire as well as to get a deeper understanding of the learners' concepts of water pollution.

This chapter presents the findings of the study and uses excerpts from the interviews, explanations and free response items to support the findings. A report will be given on the learners' performance and evidence of alternative ideas they presented. The results are also compared with similar studies in the area of water pollution with specific emphasis on environmental issues (Chua *et.al.*, 2007). The underlying aim of the study was that the findings would serve as an exemplar for the new National Curriculum Statement which direct educators to make science teaching more relevant to the socio-cultural environment of learners by integrating science with IKS.

A related objective was that the experience gained from the study could prove useful in forming attempts directed at addressing alternative conceptions held by learners and how such conceptions could be remedied through argumentation and IKS instruction.

The findings have been grouped under the research questions, which are:

1. What are grade three learners' conceptions of the causes and effects of water pollution?
2. How effective or otherwise is an argumentation-based instruction in enhancing the learners understanding of water pollution.
3. Are the learners' understanding of water pollution related to their age, gender and social economic background.

4.2 Pre-post test results

Table 4.1 describes the average performance of the two groups in the sample on the WPQ pre-test. As can be seen from the pre- test percentage mean scores the E group was 40.90 % and the C group was 41.33 %. The standard deviations for both groups were also similar at the pre-test stage. A t-test was employed to test whether or not the difference in the mean scores of the two groups was statistically significant.

The calculated t value of the entire pre-test ($t=0.0179$; $p< 0.05$) with 36 degrees of freedom) implies that the difference is not statistically significant. Therefore it can be concluded that the two groups of learners were very much comparable at the pre-test stage. At the pre-test stage the distribution of errors for both groups were similar as well. At the post-test, the average performance of the two groups on the Water Pollution Questionnaire (WPQ) had changed considerably.

A mean of 71.75 % was obtained by the E group compared to 50.1% by the C group. This is an indication that the learners in the E group showed a greater improvement in their understanding of the concepts of water pollution than was the case for the C group learners. A t-test was employed to find out whether or not the difference between the mean scores of the two groups was statistically significant.

Table 4.1 shows a highly significant difference between the pre-and post-test percentage mean scores of the E group ($t = 18.643$; $p < 0.05$) compared to that of the C ($t = 9.888$; $p > 0.05$) rejecting the null hypotheses expecting no significance difference between the two post-test mean scores. The implication of this is that the E group probably benefited more from the Dialogical Argumentation Model (DAIM) than the C group exposed to traditional instruction.

Table 4. 1 Performance of the experimental and the control group on the WPQ.

Experimental Group				Control Group				E group versus C group
Pre-test		Post test		Pre-test		Post test		Pre-test
M	SD	M	SD	M	SD	M	SD	t-value=0.0179
40,9	4.73	71.75	9.48	41.3	6.47	50.11	5.47	Post-test
Pre-test versus post-test				Pre-test versus post-test				t-value=8.4938
t-value=18.643				t-value=9.888				

The mean percentages of learners' responses to the items in the pre- and post-test of the WPQ are presented in Table 4.2. The analysis that follows hereafter focuses on comparing the features of the prevailing alternative conceptions held previously by the learners at the pre-test stage and their shift away from these alternative conceptions at the post-test stage. This information is of vital importance within the context of the study since each question represents a particular conception of water pollution.

Table 4. 2 Pre-post test results of the responses of questions of E group of the WPQ

	Mean	Std. Deviation	Std. Error Mean
Totals for pre-test content	41.65	4.380	.979
Totals for post-test content	71.75	9.475	2.119
Question 1: Pre-test	16.05	1.820	.407
Question 1: Post-test	27.25	2.489	.557
Question 2: Pre-test	4.75	1.164	.260
Question 2: Post-test	9.15	1.424	.319
Question 3: Pre-test	5.30	1.218	.272
Question 3: Post-test	12.00	1.806	.404
Question 4: Pre-test	1.40	.883	.197
Question 4: Post-test	3.10	.718	.161
Question5: Pre-test	2.90	.788	.176
Question5: Post-test	4.85	1.089	.244
Question6: Pre-test	4.30	1.174	.263
Question6: Post-test	9.25	.851	.190
Question7: Pre-test	3.75	1.372	.307
Question7 Post-test	7.25	1.118	.250
Question7: Pre-test	3.26	.733	.168
Question7 Post-test	7.05	.848	.195

N = 20

For ease of reference, it was considered useful to group the various related questions together for discussion purposes. For instance, questions 1-8 deal with the causes and effects of water pollution as well as argumentation, except for question 4 that deals with the indigenous method of water purification.

Table 4. 3 Paired sample test of E group

	T	p. level
	Totals for pre-test content	Totals for post-test content
	-18.764	.000
Question 1: Pre-test- Question 1: Post-test	-19.832	.000
Question 2: Pre-test- Question 2: Post-test	-14.139	.000
Question 3: Pre-test- Question 3: Post-test	-14.962	.000
Question 4: Pre-test- Question 4: Post-test	-8794	.000
Question 5: Pre-test- Question 5: Post-test	-6.833	.000
Question 6: Pre-test- Question 6: Post-test	-16.322	.000
Question 7: Pre-test- Question 7: Post-test	-8.882	.000
Question 8: Pre-test- Question 8: Post-test	-14.563	.000

N =20

Table 4.3 summarizes the overall paired sample comparisons of the pre- and post test scores of all the items obtained by the E group on the WPQ. The pre-test data gathered with the WPQ of each item revealed that the learners indeed held prior conceptions of water pollution. The results of the post-test of each question is less than the 0.05 which shows a significant difference between the results from pre to post test. Table 4.3 shows a very high significant difference between the pre-and post-test percentage of Q2 of the E group ($t = 14.139$; $p < 0.05$) with 19 degrees of freedom.

4.3 Further exploration of pre-post test results

This section reports excerpts derived from some of the learners' responses to items of the WPQ, interviews and class observations. The responses are indicative of the learners' understanding of water pollution, the cause and effect it has on the environment, people and animals and how it can be prevented. The data set in Table 4.2 indicates that there was a significant difference between the learners' performance at the pre-test and the post-test results in all the items. A more detailed analysis in this regard will follow under the research questions as such.

4.4 Research Question 1:

What are grade three learners' conceptions of the causes and effects of water pollution?

Question 1.1 and 1.2

These items require the learners to indicate how they would save a nearby river or stream from pollution. In table 4.2 there was a major shift in the learners' responses (i.e. from 16.05% to 27.25%). The t-value of the pre- and post-test mean scores stood at 19.83 ($t = 19.832$; $p < 0.05$). In Q1.1 60% of the learners in the (E) group and 62.1% of learners in the (C) group at the pre-test stage were capable of ticking of the correct word under each river, but both groups however found it difficult to provide valid reasons for their responses. In the Post-test of the (E) group 87.2 % of the learners could back up their responses with evidence whereas in the (C) group only 34% were capable of giving a reason for their responses.

50 % of the learners in the pre-test referred to picking up the dirt in the river or stream if they want to save it, whereas in the post –test there was a definite improvement of 83%. However, compared to the single statements they made in the pre-test, it is obvious that they expanded their statements in the post-test with various responses. L2 mentioned in the post-test that each family must adopt a river or stream to save it from being polluted.

This is a clear indication that she knows how to save a river or stream from pollution. According to L4's response, river pollution is a serious offence and you might end up being arrested if you don't look after the environment. See the under mentioned excerpts 1-3.

Excerpt 1:

L2: Pre-test: *I will pick up the dirt in the river.*

L2: Post-test: *The people must come to a "Save our rivers" meeting. I will throw a small letter or a flyer in their post box so that they will know when the meeting is taking place. In the meeting we will talk about the importance (importance) of water and how to stop pollution. Each family must adopt a river or stream near their house and keep it clean.*

Excerpt 2:

L4: Pre-test: *I will remove all the trash that makes the river dirty and filthy.*

L4: Post-test: *Put up a "Save our river" poster by the nearest shop for the people to see. I will clean the river and put up a "No dumping sign" or I can tell the people to stop polluting our rivers. If the people pollute the river, then I will take a photo of them with my celfone (cellphone) and fone (phone) the police to arrest them for polluting our rivers because they don't look after the enviment (environment).*

Excerpt 3:

L3: Pre-test: *I will pick up the dirt in the river.*

L3: Post-test: *Get people to clean the river and put up a no dumping sign next to the river so that the water creaches (creatures) can live. Tell the factory not to throw cemicals (chemicals) in the river. Move informal settlements away from rivers. They pollute it.*

Question 1.3; 1.5; 1.6 and 2.5

These items focuses on why River A will be less polluted than River B. Learners also had to identify the differences between the two rivers and indicate which river they like and why. In the Pre-test 64% of the learners could easily see the differences between the two rivers and state why River A is less polluted than River B. 70% of the learners liked River A because it had no dirt in it.

In the Post-Test 96% of the learners observed the differences between the two rivers and also stated why River A is less polluted than River B. It was also very easy for them to point out what river they liked and why. A closer look at their explanations given in the Post-Test indicates that the learners had grasp this question very well as can be seen in excerpt 3 which was quite interesting.

Excerpt 4:

L1:Pre-test: *The people don't throw dirt in the river like paper, bottles, stiks(sticks) and tins.*

L1:Post-test: *The river looks pretty because the people who live near river A looks after the environment. They don't throw rubbish (rubbish) in the river and treat the river with respect. The fishes are happy and jump around because the river is clean and not murky. The fishes can breth (breathe).*

L3: Pre-test: *The river is not filled with dirt.*

L3: Post-test: *The river is clean because the people don't pollute the river. The people don't throw dirt in the river and that is why the children swim in the river . There are many plants, trees and animals next to the river and I like this river because you can have a picnic by this beutiful (beautiful) river. The people throw their papers and tins in a dirt bin because I don't see dirt in and around the river.*

L6: Pre-test: *The water is not smelling and it is not grey.*

L6: Pre-test: *The water is very clear. It is not brown and murky because there is no dirt in.*

L4: Pre-test: *The river is clean. I see no dirt and junk in it.*

L4: Post-test: *People don't live next to the river and they don't built (build) houses next to the river.*

Question 1.4 and 2.6

In this question the learners had to state what measurements they will put in place so that the polluted river can look like the clean river.

Excerpt 5:

Pre-test: L1: *I will not throw papers, tins and bottles in the water.*

Post-test: L1: *I will not allow people to built (build) houses near the river or use it as a toilet. I will go talk to the people living near the river and tell them that there is not enough fresh water for all the people, animals and plants. I will give dirt bins to the people to throw in their rubbish.*

Pre-test: L5: *I will take out all the dirt.*

Post-test: L5: *Factories must be built far away from rivers. They must not through (throw)the chemical waste in the river. I will put up a no dumping sign by the river.*

Pre-test: L3: *I will make the river pretty again.*

Post-test: L3: *I will plant, trees, grass and flowers nex (next) to the river to make the ground or sand tight so that the sand don't blow away. Clean rivers make the environment pretty and that is why I like clean rivers.*

Pre-test: L6: *River B is polluted of the dirt.*

Post-test: L6: *The river is polluted becose (because) people live too near the river. They don't have right toilets and use the river as a toilet. They throw dirt in the river like papers, tires (tyres), tins. There is also old cars dumpd (dumped) in the river. The fishes in the river is dead of the factories waste and ther (there) is no oxygen for the fishes. There is germs in the water. A board tells the people not to swim there.*

In the pre-test 53% of the learners identified why river A was less polluted than river B. They found it difficult to give other ideas other than referring to dirt. Whereas over 90% of the learners in the post-test explained and elaborate why they found River A beautiful. Likewise, L2 and L3's responses indicates that they are concerned about the environmental problems people are causing and that it can destroy planet earth. 82 % learners had knowledge about what polluted water can do to the environment, people, animals and plants.

The learners also showed that there is a direct linkage between water pollution and the environment and this is quite clear in their responses. All the learners were able to identify the differences between the two rivers.

In Q 1.4 39% of the learners in the pre-test mentioned that they will remove the dirt from the river, if they want to improve River B's appearance, whereas 82.1% learners indicated in the post-test that they will have a cleanup campaign to pick up all the dirt in the water so that the animals living in the water may not die. They also mentioned that they will not allow people to build informal settlements near the river or use the river as a toilet. 59 % stated that factories must not be build near the rivers because they will empty their dirt in the river. 50.2% indicated that they will plant trees, grass and flowers to keep the soil firm so that the wind can't blow it away. It is obvious that in the post-test the learners responses were more in depth as in the pre-test. More than 90% of the learners could clearly state why River B is polluted by referring to different types of pollutants that is noticeable in the river.

Question 1.7 and 1.8

In this question the learners had to write five sentences on both rivers and give it a title. They then had to colour it in. In the pre-test 73.3% of the learners' sentence construction were simple and they did not expand on it. Their titles ranged from the dirty, clean or beautiful river. In the post –test there was a significant change in how their sentence construction improved. 88.4% did not just referred to dirt as a pollutant, but also mentioned other river pollutants as chemical waste, acid rain, informal settlements, using the river as a toilet and pesticides. They also mentioned the effects polluted water will have on people and the environment. 34% of the learners sentences was written in the form of a story. They chose interesting titles and some ranged as follows:

River A:

Pre-Test

L4: The clean river

L2: The jolly river

L5: The beautiful river

Post-Test

L4: The most amazing river in the world.

L2: The cheerful river.

L5: The sparkling river.

River B

Pre-Test

L3: The dirty river.

L8: The ugly river.

L5: The polluted river

Post-Test

L3: The unhygienic (unhygienic river).

L8: The crying river.

L5: The horrible river.

It's obvious that in the pre-test some of the learners were confused as to what the colour of a clean and polluted river is. In the pre-test 50% of the learners coloured the water blue in the clean river with green surroundings. 46 % coloured the water brown and 4 % did not colour in the river and surroundings at all. 70% of the learners coloured the water in the polluted river brown, as well as the surroundings. 24% coloured the polluted river blue with green surroundings and 6% coloured the polluted river green brown with green surroundings.

In the post-test there was an indefinite change. 100% of the learners coloured in the clean river blue with beautiful surroundings, indicating the beauty of the environment. 96% of the learners coloured in the polluted river brown with black-brown surroundings and 4% of the learners coloured in the river grey with brown surroundings.

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4.5 The role of language in understanding conceptions of water pollution.

Cloze test results

In Question 2 the learners had to choose the correct word to complete the sentence. There was a major shift in the learners responses from 4.75% in the pre-test to 9.15% in the post-test. As seen in Table 4.2. A t-test was employed to find out whether or not the difference between the pre- and post test responses of question 2 was statistically significant. Table 4.3 shows an extremely significance difference between the pre-and post-test percentage of Q2 of the E group ($t = 14.139$; $p < 0.05$) with 19 degrees of freedom.

The effect of language on the learners' conceptions of water pollution was initially identified as a major language barrier in the pre-test for both groups to be investigated. This was however not possible as most of the learners language of instruction differs from their home language. Many of these learners only speak English at school, because their parents are Afrikaans speaking. According to Viljoen (2001) political changes in South Africa has urged non speaking English parents to enrol their children in English- medium schools, despite the fact that their home language is Afrikaans.

Being a Foundation Phase teacher for thirty years I have seen how these young learners' languages skills have deteriorated especially where home language and language off instruction is not the same. These learners also find it extremely difficult to express themselves in clear English. In my opinion the use of incorrect words were not due to the lack of understanding, but relatively the use of wrong terminology and the lack of language skills makes it difficult for these learners to express them verbally and in writing (Fraser, 1999; Linder, 1993).

Foundation Phase learners enjoy socio-scientific topics and many a times in class they will switch over to their home language in order to express socio-scientific concepts. According to Mckeen (2000:45) Science learning will improve tremendously when serious attention is given to language skills. Rosenthal (1994:46), also claims that students with low English proficiency experience many difficulties in understanding scientific concepts in English. Nonetheless, I believed that language had some influence on the study with regard to the pre-test of both groups C and E as well as the post-test for the C group only.

I observed that many learners in the C and E group could not write their responses of the WPQ in clear English to make it comprehensible to the teacher. Language was recognized as one of the problems that had an influence on reading and interpreting questions and writing clear written and oral responses. The improvement in the E group’s language ability was probably due to the fact, that a vocabulary list was drawn up to help learners with the meaning of difficult scientific concepts. This was revised on a daily basis so that learners were able to understand and use the words meaningfully.

Table 4. 4 Learners’ performance on the cloze test

Control Group (C)				Experimental Group (E)				E group versus C group
Pre-test				Pre-test				Pre-test
N	M	SD	SEM	N	M	SD	SEM	t-value = 0.4170
18	4.28	4.92	1.16	20	4.75	1.16	0.26	df =36
Pre-test				Pre-test				Post-test
N	M	SD	SEM	N	M	SD	SEM	t-value = 10.1272
18	3.17	2.18	0.51	20	9.15	1.42	0.32	df=36

Table 4.4 describes the averages performances of the two groups in the sample on the WPQ pre-test of the cloze. As can be seen from the pre- test percentage mean scores of the (E = 4.75 %) and the (C = 4.28 %) and the standard deviation of both groups, the learners performance were similar, before the research intervention commenced thus indicating that both groups were on the same conceptual level of water pollution. A t-test was employed to test whether or not the difference in the mean scores of the two groups was statistically significant. The calculated t value of the entire pre-test (t=0.4170; p< 0.05) with 36 degrees of freedom implies that the difference is not statistically significant.

Therefore it can be concluded that the two groups of learners were very much comparable at the pre-test stage. As can be seen from the analysis of the cloze test scores of the (E) group there was a major shift with regard to the results (4.75% to 9.15%) in the post-test. The calculated t value of the entire post-test ($t = 10.1272$; $p < 0.05$) with 36 degrees of freedom implies that the difference is statistically significant.

Question 3

In question 3 of the WPQ the learners had to observe a picture of a river flowing through a community and identify the different ways in how the river is being polluted by encircling it. They also had to say what effect polluted water will have on people if they drink it. 100% of the learners could easily identify where the people in this community get their water from. 97% of the learners were able to identify the items that polluted the river.

In the Pre-test 37% of the learners knew that you can get sick when drinking dirty water and only 5% indicated that polluted water can cause a running stomach. There was a major shift in the learners responses from 5.30% in the pre-test to 12.00% in the post test. As seen in Table 4.2. A t-test was employed to find out whether or not the difference between the pre- and post test responses of question 3 was statistically significant. Table 4.3 shows the calculated t value of the entire pre- and post-test ($t = 14.962$; $p < 0.05$) with 19 degrees of freedom implies that the difference is extremely statistically significant. In the Post-test there was a major shift with regard to the learners concepts as seen in the under mentioned excerpt.

Excerpt 6:

What illnesses can Sipho's family get when they drink polluted water?

Pre-test:L3: *They can get sick or get TB(Tuberculosis).*

Post-test: L3: *When you drink polluted water you can get dieareah (diarrhoea) and dehydrate. You can also die. People can also get cholera.*

97% of the learners indicated that polluted water cannot be used for drinking or to prepare food. because it has many germs in it that can kill you. 83% of the learners indicated that polluted water has germs and cannot be used to water plants.

Some learners also mentioned that if polluted water can kill people and fishes in rivers, then it can also let plants die. 17% of the learners indicated that polluted water can be used to water plants

Question 4

In Q4 the learners had to explain the procedure on how to clean dirty water. In the Pre-Test 73% of the learners mentioned that by boiling the water all the germs in it will be killed. This misconception was cleared up after the intervention. The responses of the learners improved from 1.40% in the pre-test to 3.10% in the post-test. A t-test was employed to find out whether or not the difference between the pre- and post test responses of question 4 was statistically significant. Table 4.3 shows the calculated t value of the entire pre- and post-test ($t = -8.794$; $p < 0.05$) with 19 degrees of freedom which implies that the difference is significant. See the under mentioned excerpt of Q4.

Excerpt 7

L2: (Pre-Test) *I will first boil the water. I will close it after boiling it.*

L2: (Post-Test) *I will first filter the water. Secondly I will boil it. Then I will throw four teaspoons of jik in only if it was a bucket of water that I boiled. If I did not boil a bucket of water then I must throw less jik in I think. I close the bucket and let it stand for some ours (hours).*

Question 5

In this question the learners had to indicate which water source is safe to drink and give a valid reason for the answer. The responses of the learners in Q5 improved from 2.90% in the pre-test to 4.85% in the post-test. A t-test was employed to find out whether or not the difference between the pre- and post test responses of question 5 was statistically significant. Table 4.3 shows the calculated t value of the entire pre- and post-test ($t = -8.794$; $p < 0.05$) with 19 degrees of freedom. In the Pre-Test 51.% of the learners said that river water is safe to drink if there is no dirt in it. In the Post-Test there was an improvement in their answers and 94.2% indicated that river water is not safe to drink. See under mentioned excerpt 6.

Excerpt 8

L3: (Pre-Test) *River water is safe to drink if there is no dirt in.*

L3: (Post-Test) *If people take out the dirt in the river it is still not safe to drink becose (because) germs cannot be seen with the naked eye.*

L2: (Pre-Test) *Bottled water is safe because there is no dirt in.*

L2: (Post-Test) *Bottled water is safe to drink because it (goes) through a filtered process to keep all the germs out. Then.. then they seal the bottle.*

L5: (Pre-Test) *Borehole water is not safe because it is dirty.*

L5: (Post-Test) *Borehole water is not safe to drink because it is polluted through sand, stones and rocks that you find underground.*

L7: (Pre-Test) *Tap water is also not safe because maggots was in our tap water when we wanted to drink it long ago.*

L7: (Post-Test) *Tap water is now safe to drink because there is no more maggots in it. The people cleaned the water but maggots can come in the water again. I only drink bottled water now. I am too scared to drink tap water.*

In the Pre-Test more than half of the learners (54.1%) mentioned that borehole water is not safe to drink because it is dirty. Whereas in the Post-Test 71% also said that borehole water is not safe to drink. In both the Pre-and Post-Test 100% of the learners said that bottled water is safe to drink .In both the Pre-and Post-Test 100% of the learners mentioned that sea water is not safe to drink because it is too salty. In the Post-Test 69% of the learners also indicated that salt water is not good for the body because it can make you sick, damaged the organs in the body and cause you to die.

All the learners except one in the Pre-and Post-test indicated that tap water is safe to drink because there is no dirt in it. In the Pre-test 100% of the learners said that fresh rain water is safe to drink because it is not polluted. In the Post-Test their views changed. 73% said that fresh rain water is also not safe to drink because it mixes with smoke that pollutes the air and that makes it no more fresh and safe to drink.

Question 6 (6.1, 6.2, 6.3)

Q6 attempts to probe the learners' critical reasoning of a comic strip they had to read and thereafter agree or disagree with the questions by providing valid reasons for their answers. In this question the learners responses improved from 4.30% in the pre-test to 9.25% in the post-test. As seen in

Table 4.2. a t-test was employed to find out whether or not the difference between the pre- and post test responses of question 6 was statistically significant. Table 4.3 shows the calculated t value of the entire pre- and post-test ($t = -16.322$; $p < 0.05$) with 19 degrees of freedom.

In Q6.1 85% of the learners in the pre-test found it difficult to provide a valid reason why the mother did not want her son to play in the water. There was however a major change of 94% in the post-test with regard to the learners responses. In Q 6.2 27% of the learners indicated in the pre-test that the water is clean whereas 87% of the learners in the post-test disagreed by stating that germs can't be seen with the naked eye. In Q6.3 43.2% mentioned in the pre-test that the mother is in a bad mood therefore she did not want her son to play in the water. Whereas in the post-test their views changed to 79%. See the underneath excerpt.

Excerpt 9

Why does the mother not want the boy to play in the water?

L1: (Pre-Test) *She is in a bad mood.*

L1: (Post-Test) *The water is dirty and the boy can get sick because of the germs that is in the water and he can also die.*

According to the boy, the water is clean. Do you agree or disagree? Give a reason.

L5: (Pre-test) *I agree. It looks clean.*

L5: (Post-Test) *I disagree. A person can't see germs with the naked eye. Germs are too small.*

Is the mother really in a bad mood? Yes or No and explain your answer.

L3: (Pre-Test) *She is in a bad mood because she do not want her son to have fun.*

L3: (Post-Test) *She is not in a bad mood. She cares for her son and do not want him to get sick. There is germs in the water and the boy can get a waterborne disease like cholera.*

Question 6.4

In Q 6.4 learners had to agree or disagree with the given statements by ticking it off in the correct column. In Q 6.4.1 58% of the learners in the pre-test agreed that water pollution takes place when people dump waste in it whereas in the post-test all the learners agreed. The result of this particular

question was quite interesting and took a different venture. One would foresee that this was straight forward to the learners, however of the 100% of the learners that agreed more than a third (73%) also ticked off disagree on the questionnaire. They wrote that water pollution can also take place through pesticides, factory waste and also mentioned smoke coming from vehicles and chimneys as well as acid rain.

In Q6.4.2 38.2 % indicated in the Pre-Test that filtered water is free of germs. Likewise in the Post-Test 73% of the learners responses showed an improvement in their answers. In Q6.4.3 48.2% agreed that polluted water is dirty, smell bad and contain germs that are harmful to people, animals and plant life that can cause diseases. In the Post-Test there was a dramatic change to 92.3%.

In Q6.4.4 17.4% of the learners in the Pre-Test said that the environment can be destroyed by the pollution of rivers with regard to 92.1% in the Post-Test. In Q6.4.5 13.2% agreed in the Pre-test that germs in water can be seen with the naked eye whereas in the Post-Test their views changed to 100% . In Q6.4.6 51.4 % of the learners agreed in the Pre-Test that polluted water can be cleaned for drinking whereas in the Post-Test there was an improvement to 89.5%.

Question 7 and 8

In question 7 and 8 learners had to indicate the water wasting and water saving actions. The learners had to provide a reason for the given answers. In Q7 of the WPQ the learners responses improved from 3.75% in the pre-test to 7.25% in the post-test. In question 8 of the WPQ it improved from 3.26% in the pre-test to 7.05% in the post-test. As seen in Table 4.2. a t-test was employed to find out whether or not the difference between the pre- and post test responses of question 7 and 8 was statistically significant.

Table 4.3 shows the calculated t value of the entire pre- and post-test of question 7 ($t = -8.882$; $p < 0.05$) with 19 degrees of freedom and question 8($t = -14.563$; $p < 0.05$) with 18 degrees of freedom. In the Pre-Test of Question 7 and 8 more than half of the learners (51.1%) indicated the following water saving measures: taking a shower instead of a bath; using a bucket of water to wash a car, instead of a garden hose; collecting rain water in a tank and using a spray can to water flowers. The given reason was to save water. In the Post-Test of question 7 and 8 more than 89% of the learners could easily identify the water wasting and water saving actions.

4.6 Interviews

A focus group interview (n8) was done. The interview questions required learners to indicate their understanding and reflect their knowledge on the causes and effects of water pollution and the environment as such in relation with IKS. These questions were directly linked to the WPQ as to triangulate (Vulliamy et al., 1990) the findings in the WPQ. Learners were asked four questions. The first question was:

What is your understanding of water pollution?

Excerpt 10

L1: C (Pre-Test) *When the water is ... dirty and people throw papers in it.*

L1: C (Post-Test) *The water is full of.. of.. dirt like papers, tins, bottles and other stuff.*

L1: C (Post-Test) *Polluted water looks black or brown from the dirt or dust. If people litter, then they are not worried about the earth.*

L2: E (Pre-Test) *The water is dirty orr.. filthy. People throw papers, tyres, bottles, tins and many dirt in the water. The water also change colour.*

L2: E (Post-Test) *Water is polluted when there is many dirt in it. If people don't stop littering in water, then they don't care about the environment and water is also polluted when... fac... factories let the chemical waste in the rivers. Plants th... that grow in the water can then die and also the fishes and other animals that live in the water can also die.*

Excerpt 10.1

Teacher: Why are rivers more polluted today than in the past?

Transcript of learners integrating IKS with science concepts above.

L5: *Now I once again agree with L4 when she told us about the gods that punish people in Ghana if they pollute the rivers in their community.*

L3: *The gods wanted the people to care for the environment.*

L2: *I agree with you. If they care for the environment, then they will not pollute the rivers and the animals in the water will live.*

L4: I think the gods did something good. The people were scared of the gods, that's why they only went to fetch water by the river when they needed it.

L2: If the people don't harm the river, then they will also have food to eat like fish.

L3: S..so the people really believed that the gods would harm them, that's why they lived very far from the rivers and the children did not even played by the rivers.

L1: Th... that's why there's no factories near the rivers.

Excerpt 10.2

L1: E(Post-Test) Farmers also spray the crops with pesticides and when it rains the pesticides mix with the ground, I..I.. mean the soil and then it flows into the rivers and pollutes the water.

L3: E(Post-Test) The smoke that pollutes the air mixes with the rain and it causes acid rain and... it goes into the rivers.

L4: E(Post-Test) That's not right. I mean you..you are right but ..but.. you forgot to say that it lowers the oxygen level in the water and this causes the fishes to die.

L3: E(Post-Test) I know the answer but you were rushing me and it's not fair.

L4: E(Post-Test) People also pollute water when they use it as a..a.. toilet and they can get very sick.

L3: E(Post-Test) When people drink polluted water they can get a waterborne disease ll.. like cholera ...mmm.. When they have cholera they also get diarrhoea. People can die of a waterborne disease.

L4: E(Post-Test) Polluted water change colour because of the dirt in it. It can be murky, black or brown and there is also a lot of germs in polluted water. If it shines on top then oil polluted the water.

Excerpt 10.3

Transcript of learners integrating IKS with science concepts above.

Teacher: Why were rivers not so polluted in the past?

L3: *I used to live with my grandma in the Eastern Cape before coming to live in Cape Town with my father. She lived in a rural area. Early the morning my grandma and I had to go fetch water by the river. The river is very far. It is the woman's duty to go fetch water where I use to lived.*

L2: *Why can't the men fetch the water?*

L4: *It is not their duty to do it. That is how we do things in the rural areas.*

L3: *What is a rural areas?*

L4: *I...it's like living on a farm. The schools, houses and rivers are very far from you. When we go fetch water then I must not run in the river, because my grandmother says the ancestors will get angry because I will disturb the animals in the water and also pollute it.*

L4: *Who is the ancestors?*

L3: *It is our forefathers. Your grandfather's father's and so on...*

L1: *Oh, now I know. The ancestors are like the gods of Ghana. They want people to look after the water and not waste it. They must also look after the environment.*

L4: *My grandmother says that the ancestors respect water because it is powerful and we must listen when the ancestors speak to us or something bad will happen.*

L1: *That is why there must be no houses near the rivers so that people can't pollute the river which will cause people to get sick.*

L2: *My dad told me that in the olden days they travelled with a horse and cart to places. This did not pollute the air and acid rain did not lower the oxygen level of the water causing animals in the rivers to die.*

Excerpt 10.4

L2: E(Post-Test) *"What goes down the drain comes back again."*

L1: *Can I explain learner 2's claim?*

Researcher; *It's for Learner 2 to decide.*

L2: *No, I want to explain it myself. The water in the washing machine and the water of the dishes also pollutes our rivers. L1: It's called household sewage. If we throw medicine down the drain it also pollutes our rivers*

Excerpt 10.5

Teacher: How did people in the past, got dirty clothes clean, and what did they used when someone got sick?

Transcript of learners integrating IKS with science concepts above.

L3: *My grandmother told me that they did not have a washing machine. They washed their dirty clothes in a bath and then they rubbed the clothes on a washing plank. They did not use washing powders to throw in the water but used soap to wash it with. That means that no dirty water went down the drains. The water was thrown on the soil.*

L2: *I know what it is called. It is called blue soap. My granny told me that they made the soap themselves and only washed clothes on Mondays. That is how they saved water.*

L1: *S..so that means my mom is wasting water if she washes clothes every day.*

L5: *If all people now wash their clothes on a Monday, then we can save a lot of water.*

L4: *My ma said it was fun to get stains out of clothes in the olden days. They laid the clothes on the grass and the sun would let the stains disappear. They did not use chemicals like domestos, for stains and there was no dishwasher, to wash the dishes with. That is why the rivers did not become polluted.*

L2: *I think that the washing machine wash the clothes cleaner than your hands.*

L4: *I disagree with you. Washing your clothes with your hands also takes out the dirt.*

L2: *What proof do you have?*

L4: *I wash my own socks with my hands and it comes out clean.*

L2: *(smiling) Yes, you are right. I also washed dirty socks with my hands and it came out clean.*

L3: *I also agree with L4, because sometimes my mom throw clothes in the machine and then the stain is still on my top if she takes out the washing.*

L1: S..so the washing machine is not better than washing with your hands. It only makes life easy but it pollutes our clean water when it does down the drain.

L2: My sister throws a lot of water in the machine but only wash a few things. So she is wasting a lot of water.

L1: In the olden days my granny used herbs for medicine and she still has a herb garden. She said that my grandpa made his own cough medicine that worked and that they never bought medicine at the chemist. I will bring some herbs tomorrow and tell u what it can be used for. They did not have to flush medicine down the drain to pollute the water.

L3: In the olden days people cared more for the environment and that is why water was not much polluted.

L1: That means the people no more care for the environment and is destroying it.

It is obvious in the above excerpts that in the Pre-test of both the C and E group all the learners referred to dirt as the only means of how water can be polluted. All the learners indicated that pollution takes place as a result of people's irresponsible behaviour towards the environment. In the Post-test one learner in the C group also mentioned that polluted water can be black or brown. The learners responses in the E group changed dramatically. After the intervention, learners in the E group clearly indicated in their responses that they now know that it is not just dirt that pollutes water. They gave fuller descriptions of what they now understood by water pollution and how it is being caused. They also indicated that everything that is flushed down the drain pollutes our aquatic systems.

The learners were at first dominant to the scientific view of water pollution. (See lesson 3 activity 3 in appendix 3) After listening to what the one girl of Ghana said about their cultural views regarding the gods that punish people if they pollute water a new debate opened without delay and took another dimension. Through questioning her it slightly moved into a religious setting, but was brought back on track when the Ghanaian girl answered that it is not a real god. Whereas another learner mentioned a fake god.

Although the majority of the learners found it strange due to their scientific view, they however were more relaxed when the girl who questioned the Ghanaian girl referred to a fake god and also brought in her own experience similar to what the previous girl mentioned.

Most of the learners could identify themselves with the fake “oupa doelie” which their parents at times used in forcing them to eat their food or when they were naughty. I can also recall the terrifying days when my parents would scare me with a fake ”oupa doelie” that will steal me if I won’t stop crying. This dialogue between the learners were quite interesting. Under no circumstances did I try to steer the learners into a particular line of argument except when there was a detour e.g. if an awkward remark was made about a particular culture. This approach help them understanding different cultures.

Integrating science with IKS was justified in excerpts 10.1,10.3 and 10.5 Both thought systems of the learners were dominant. There were also valid grounds in putting together the two distinct worldviews through dialogue so long as it was not counterproductive or compromised the integrity of either science or IKS (Ogunniyi, 2007). It was also now much easier for the learners to understand why the rivers were not polluted in the past with regard to now. The fact that some cultures feared the gods, caused the people to live in harmony with the environment. Therefore the people were only allowed to go down to the river to collect water. Under no circumstances were they allowed to live or play near the river.

In excerpt 10.1 the learners realized that gods and ancestors are more or less the same thing and that both are there to protect the environment as well as people, animals and plants. That water is seen as a powerful source and must be respected at all times. One respondent mentioned that the majority of the people had a horse and cart which prevented air pollution. Another respondent mentioned that people saved more water in the past, due to the fact that only Mondays, was known as a washing day. Also, the soap people used was made by themselves and that they used the sun to get rid of stains instead of chemicals. Another respondent mentioned that people used natural herbs when they were sick and in this manner people took ownership of the environment and nothing went down the drain to pollute our rivers.

The majority of the learners indicated that smoke pollutes the air and that it consists of poisonous gasses that can make people and animals sick and even kill them. They furthermore revealed that when smoke mixes with rain it becomes more harmful when they enter water since it is now acid rain. In my opinion I thought that the learners may find this part a little difficult but without doubt they were able to explain it in more detail during the interview.

These excerpts seem to validate the fact that there is some connection between the ideas of these 7-9 year olds and those of secondary students (Mohapatra and Bhadauria, 2009:73) with regard to their responses of acid rain polluting our water systems. In the second interview question it was required of the learners to state what effect polluted water will have on people. Most of the learners in the Pre-test of both the C and E group mentioned that polluted water can make people sick and that they can die.

However in the Post-Test the learners in the E group gave some interesting responses indicating different ways of how polluted water can effect mankind as well as the environment. All eight learners stated that polluted water can give you a waterborne disease and that it can make you seriously ill and may cause you death. Besides destroying the environment like trees, it can also harm our aquatic life. One respondent mentioned that people need to take care of the environment and water or the earth will be destroyed and that parents must tell their children not to litter. See the excerpt beneath.

Excerpt 11

L3: E(Pre-Test) *People can get sick and their tummy can pain.*

L3: E(Post-Test) *When people drink polluted water they can get a waterborne disease ll.. like cholera ...mmm..or typhoid fever. When they have cholera they also get diarrhoea. People can die of a waterborne disease.*

L2 C: (Pre-test) *They can get sick.*

L2:C:Post-Test): *They can die if they drink polluted water because it can give you a running tummy.*

L4 E: (Pre-Test) *The people can get very, very sick.*

L4 E:(Post-Test):*If you drink polluted water you can get a waterborne disease like cholera or typhoid fever. U can also get a running stomach.*

More ideas came forward during the second interview question in the Post-test of the E group.

L3: *A running tummy is called diarrhoea. A person can dehydrate if he.. he.. has diarrhoea.*

L5: *You must have water in your body. If there is no water in the body then the organs will dry out and will not work. I mm...mean function correctly.*

L1: *Polluted water will destroy planet earth. If you water the vegetable garden with polluted water, the germs will destroy the food that we plant and ..and then the vegetables will die and there will be no food, I mean nnn...for the people to eat.*

L2: *If animals drink polluted water they will die and people will have no meat to eat. L6: People will also have no fish to eat because acid rain lowers the oxygen level in the water and this let the f..fishes also die. We need to count every drop, because every drop counts. I say this so that people must save water and not waste it. L8: The soil will dry out and plants will struggle to grow.*

In the third interview question learners had to indicate how polluted water could be cleaned to make it drinkable. In the Pre-test of both groups (C and E) most of the learners mentioned that you can boil water to make it clean and then drink it. One learner in the C group stated that the municipality clean the water to make it drinkable, but she was unable to clarify how it is being done. In the Post-Test learners views changed tremendously with regard to their responses. Most of the learners in the C group stated that after boiling the polluted water, you need to throw bleach in it and allow it to stand for a few hours.

They however could not say what the purpose of the bleach was. In the post-test of the E group five learners mentioned that polluted water needs to be boiled and then a spoon of bleach has to be thrown in to kill the tiny germs that cannot be seen with the naked eye. One of the E group learners (L3) indicated that the municipality throw chemicals in polluted water to purify it so that the water can be used again and again for people to drink. This clearly showed the learners' understanding of water recycling. In a dramatic turn another learner (L4) in the E group commented on the learners (L3's) response with regard to the municipality.

L4 indicated that her father also throw chemicals (Blue 52) in their swimming pool to kill the tiny germs in the water. She also mentioned that before you swim in the pool, u need to take a shower as a precautionary measure to protect the skin against the chemicals. L3 raised the following question to L4: *If u need to protect your skin against the chemicals that has been thrown in the pool, how safe is the chemicals that the mu...muni.. municipality throw in our water to make the drinking water safe?*

L3: *If the chemical was not safe, then many people would have died by now, which is not the case.*

L4: *I read in a book that people can get cancer.*

L3; *That's not enough evidence. If you can bring the book to us so that we can read it ourselves*

L4: *I don't know if we still have the book*

In the last question learners had to indicate several ways in which one can save water and not waste it at school and at home. Learners had to provide their knowledge and understanding of water conservation. Most of the learners mentioned in the pre-and post-test that pre-cautionary measures should be taken in order to preserve the earth. All the learners stated that effort should be undertaken to save water at home e.g. using the shower instead of the bath. The reason given for this statement by three learners was that one uses less water when the shower is used instead of using the bath.

Another learner also mentioned that a bucket could be put in the shower as to collect some of the water while showering. This water can then be used to wash cars. The majority of the learners indicated that one needs to close the tap while brushing teeth to prevent clean water from running down the drain since there is not enough fresh water available for people on earth. Six learners mentioned that rinsing vegetables under a running tap is a waste. They also stated that if water is thrown in a bowl and then used to rinse fruit and vegetables a lot of water will be saved. One learner said that the water used for rinsing vegetables can be used for drinking after it has been boiled.

Another learner interrupted her and said: “If dirty water is boiled, it is still not free of germs.” According to L2, “Germs can’t be seen with the naked eye, and you have to kill the germs by throwing in bleach and let it stand overnight”. The interview with the learners became very argumentative as they wanted to know one thing or the other.

The excerpt below is representative:

L3: “After the vegetables have been rinsed in the water, I know that the water is no more clean because there is little sand in the water and the water change colour. I mean it is murky”

“When my mother rinse the vegetables there is always sand left in the sink. Can this polluted water be thrown on flowers?” Will it not kill the plants in the garden?

Before I wanted to open the question to all the learners a girl (L1) answered by saying the following: *“I don’t think the plants in the garden will die because the vegetables are clean and have been rinsed off”*.

Then L4 (half agitated) answered: *“Ho...how can it be clean? The.. the.. farmers spray pesticides on the fruit an..and also on the vegetables. I think there can still be pesticides on the vegetables even if it is rinsed.”*

L2 then stated: *“When we wash our hands, we think it is clean and...and I think there are still tiny germs on our hands which we cannot see with the naked eye. S..ss..so I don’t know if our* What an interesting argumentation session it was. It was obvious that all the learners knew that when drinking water without a cup is wasting water.

L3 mentioned the following:, *“When people don’t drink with a cup they waste the clean water coming out of the tap and it goes down the drain.”*

L5 also mentioned the following, *“If a tap drips, clean water goes down the drain and it is being wasted. Our bathroom tap dripped and my daddy had to pay a lot of money for the water. After that he fixed the tap and he did not pay a lot of money for the water”. Are our hands really clean after we washed it.”*

One respondent mentioned that water can be saved if you throw water in a bottle and only used it when you thirsty and then keep the other water in the fridge.” L6 stated that, *“Water can be saved if you collect water from the rain because it can be used for drinking.”*

L3 then asked, “*How c...c... can rainwater be clean when the smoke that pollutes the air mixes with rain and cause acid rain?*”

L2 added that, “*Rainwater can be used to water the garden, wash the car and also your clothes.*”
L4 “*I drank rainwater already and I did not get sick. S..ss I don’t think people will die from it if they drink it.*”

L1, “*Water can also be saved if you don’t use a hosepipe to water the garden because you waste a lot of clean of water. You can water the garden by using a bucket and splash the water on the flowers.*” L5 also added that, “*We can also use rainwater or sea water to flush the toilet instead of clean water.*”

4.7 Research Question 2

How effective and otherwise is an argumentation-based instruction in enhancing the learners understanding of water pollution?

The argumentation scheme underpinning the classroom discourses based on the Science and Indigenous Knowledge Systems Project (SIKSP) in the School of Science and Mathematics Education, at the University of the Western Cape is shown in Figure 3.1. The various tasks normally begin with brainstorming (individual argumentation), to small group and finally the whole class argumentation session. It is at this stage where consensus is finally reached with the help of the teacher acting as a facilitator of the whole process (Ogunniyi, 2007a &b, 2009).

The findings of this study seem to agree with earlier findings of Keogh, Naylor, Downing, 2003 (p. 12) that young children of age seven to nine are capable of constructing arguments through collaboration, verbal interaction by making claims, providing evidence and even come up with a rebuttal through cognitive harmonization in small groups (Ogunniyi, 2008). In order for young learners to argue effectively they need to be taught the value of purposeful listening, so that these listening skills can be used to verbalize their thoughts through thinking, reasoning and developing the ability in forming arguments (Simon., Erduran., Osborne; 2006).

For ease of reference and in terms of Toulmin's Argumentation Pattern (TAP), the learners' claims, reasons or grounds (i.e. evidence, warrants, and backings) and rebuttals are displayed in Tables 4.5-14 that follow. During dialogical argumentation in small group discussions, group presentations and whole class mediation the following words were constantly part of the learners' vocabulary. Words like agree, disagree, claim, evidence, agreed upon, proof, I think, because, comment, argue, agreement, valid, raise, good argument, strong point, listened, attentively, guide, explain, identify and assist were constantly part of their new vocabulary.

It was obvious during the study that when the learners used the above words it resulted in a good argumentation discussion. The majority of the learners precisely knew that if the answer is right and evidence was provided that they have to agree and if it is wrong that they have to disagree I however wish to state that the learners in this study also used other words as mentioned above which resulted in stronger arguments. These words also prompted the other learners to participate. These findings correspond with those of Mercer et al (1999) who states that children argue better when they use significant words like because, I think, uses agree and take long turns in talk in discussions.

Some learners experienced difficulty distinguishing between a claim and evidence at the beginning of argumentation and some of them also cried as this was something new to them. At times I could see their eyes looking at me and silently crying out for help. But from my side it was only some words of motivation that kept them going. "*You can do it angel. Don't give up* " Other learners in the group were eager to assist when they realized that their group member was in difficulties. "*Miss can I guide her.*" At the beginning of argumentation, the learners thought that they are being criticize, and they became very emotional.

As time passed their tears dried up and they were now emotional stronger and able to justify their As Naylor., Downing, and Keogh (2001) indicated that when children argue they become very emotional and especially when they argue scientifically it has a powerful and emotional undertone. Before making their claim known to the rest of the class, they would reach a common agreement in their group. What outshined argumentation in the study was when some of them also came up with a single rebuttal. During class observations and transcribing of the video recording it was evident that while they argued they were very confident and all the learners started their arguments with one of the following phrases which made their argument stronger.

“I agree with what you said but can you give more evidence for your claim.”

“You raised a good point but can you explain it to me.”

“I disagree with you because.”

“I disagree with you because what you said don’t make sense.”

“I want to comment on what you said.”

“I agree with your claim but you could have mentioned that.”

“I think your point is valid and I agree with u.”

“You did not listen attentively because you are not answering the question.”

The longer the learners became involved in reasoning and questioning each other’s claims, even coming up with counterclaims the more they excelled at it. At the start of argumentation, the shy and quiet learners kept to themselves and just observed everything. The only indication they gave was a smile or nodding their heads. Some learners took very long while arguing, but what they said made sense after all. It was quite remarkable to see how the quiet learners gradually engaged in argumentation and how it became part of them too.

It was so amazing when the learners also used the same terminology as stated earlier in mathematics, aloud comprehensive reading, sentence writing and in normal conversations on the playground. It was evident in the study that the learners whose listening skills have been fully developed, were able to listen attentively and engage successfully in dialogical argumentation. The children in this study constructed arguments on different levels as drawn on Ogunniyi’s Dialogical Argumentation (2008) as depicted in chapter 2. This model was used to determine the argumentation level of the learners in the study.

The transcripts below indicates how four groups of 7-9 year olds constructed different views on water pollution and reached a common agreement in the end. Through dialogical argumentation they made well grounded arguments, by reasoning with each other and by providing evidence to support their claim. They reflected on their own thoughts and that of others which resulted in a clearer understanding on the causes and effects of water pollution.

After each group discussion they reported back to the rest of the class based on Ogunniyi's (2008) Dialogical Argumentation. Each group also displayed different argumentation levels based on the variety of activities below.

Group 1: Had to compare the substances in container A and B. They first worked individually in their group and compared the two containers with each other. Secondly they had a group discussion that lead to claims which resulted into arguments, providing evidence, followed by counterclaims and even a rebuttal. Eventually the learners in the group reached consensus that the substance in container A is clean water after all. The argumentation level of group 1 is analyzed in the table below.

Table 4.5 Group 1 learners co-constructing an argument on container A

Learner	Claim	Grounds	Counter Claim	Grounds	Rebuttal	AL
L1	<i>Container A is clean water...</i>	<i>There is no dirt in it.</i>				L2
L3			<i>L1 said water but...I th..think it can perhaps be rain water or tap water.</i>	<i>It has no smell. It is a liquid. It takes up the shape of the container</i>		L3
L5	<i>I also agree that it is tap or rain water.</i>	<i>The water is crystal clear and transparent.</i>				L4
L3			<i>It can also be cool drink.</i>	<i>It smells like lemonade cool drink. It is also transparent.</i>		L5

The learners in Table 4.5 were co-constructing arguments through dialogue. Although they were very excited to respond to each other's claim by way of their body language they interrupted each other. Their arguments appeared to be well focused and they used evidence to justify their claims or counter claims. L3's counterclaim that there was cool drink in the bottle and not water, because of its smell. was followed by a direct rebuttal (Table 4.6) where L6 agreed with L3 that lemonade is transparent but disagreed with him due to the fact that the container smells like lemonade and therefore it is not lemonade in the container but water. Also that lemonade has a gas in it and water not.

Table 4.6 Group 1 learners co-constructing an argument on container A

Learner	Claim	Grounds	Counter Claim	Grounds	Rebuttal	AL
L1					<i>I agree and disagree with L3. I agree that lemonade is transparent because I can see through it. I disagree with him that the substance in container A is lemonade because lemonade has a smell. The container smells like lemonade .There was first cool drink in the bottle. When the cool drink was up they then threw water in the in the empty le ..lemonade container. I think the lemonade container was not rinsed out properly because I smell lemonade on the plastic of the bottle and if it was lemonade then we had to see bubbles in it because lemonade has a gas in.</i>	L6

In table 4.6 L1's views changed dramatically. She probed deeper by generating a sufficient explanation based on evidence and appropriate reasoning to rebut L3's claim that the substance in the container is not lemonade. L1's rebuttal developed a better understanding in the group of the phenomenon under investigating.

Table 4.7 Group 1 learners co-constructing an argument on container A

Learner	Claim	Grounds	Counter Claim	Grounds	Rebuttal	AL
L2	<i>It can also be ice water from the fridge</i>	<i>It feels cold.</i>				L2
L4			<i>L2 claims that the substance in container A is ice water. I disagree because I think it is tap water.</i>	<i>When I put my finger in the, the ... water it did not feel so cold. So she did not give enough evidence to claim that it is ice water.</i>		L3
L3	<i>I agree with L4 because tap water can also feel cold.</i>	<i>When it is very cold in winter the water is colder that comes out of the tap. Raindrops can also be ice cold in winter.</i>				L4

In table 4.7 L4 disagreed with L2 that the substance in the container is ice water. She furthermore stated that L2 did not give enough evidence to support her claim regarding the ice water. L4's counterclaim that it is not ice water but tap water resulted in further dialogical argumentation in the group. Although L3 agrees with L4's claim, she provides different evidence to support it.

Table 4.8 Group 1 learners co-constructing an argument on container A

Learner	Claim	Grounds	Counter claim	Grounds	Rebuttal	AL
L5	<i>I disagree with what learner L2 said. A person cannot just feel water on the outside to say it is ice water.</i>	<i>U must take the temperature of the water with a thermometer.</i>				L5
L2	<i>I agree with L5. Ice water is colder than tap water, but there is another way to find out.</i>	<i>I will put a thermometer in the ice water and in the tap water and read the temperature of the water.</i>				
L2	<i>I agree with L5. Ice water is colder than tap water, but there is another way to find out.</i>	<i>I will put a thermometer in the ice water and in the tap water and read the temperature of the water.</i>				
L5	<i>Ice water in a bottle will cool off if it stands outside the fridge.</i>	<i>You can see and feel the wetness on the outside of the bottle. A room is warmer than the inside of a fridge.</i>				L3

L5 made an interesting claim that water cannot be felt on the outside of a bottle to determine that it is ice water. You have to take the temperature of the water. L5 stated that ice water will cool off if it stands outside a fridge because it is evident on the outside of a bottle. “The bottle will be wet on the outside. I can see it and also feel it.” The argumentation in the group was taken to another level, when L2 made an important claim by stating that a thermometer can be used to determine which substance is colder. L5 also states that the temperature of a room is much warmer than the inside of a fridge because “You can change the temperature in a fridge if you want it to be colder”. The learners came up with different ideas and engaged in good arguments with grounds

Table 4.9 Group 1 learners co-constructing an argument on container A

Learner	Claim	Grounds	Counterclaim	Grounds	Rebuttal	AL
L3	<i>I agree with L5 because it is colder in a fridge than in a room.</i>	<i>You can change the... tt..temperature of the fridge if you want it very cold so that food can't get rotten. If I put tap water in the fridge and take it out the next day then it is cold when I taste it.</i>				L4
L4	<i>I agree with L3 because it is colder in a fridge than in a room.</i>	<i>You can change the..tt..temperature of the fridge if you want it very cold. so that food can't get rotten.</i>				L5
L3	<i>It can also be flavoured water .</i>	<i>It has a smell. I.. then smelled..... smelled it.</i>				L3
L5			<i>I disagree with L3. It is not flavoured water. He first said that the substance in container A is lemonade. L1's evidence is proof that it is not, because it is the container that smells like cool drink. L3 must listen..</i>	<i>Flavoured water has a gas in. The substance in container A has no gas in it.</i>		L4
L5			<i>I disagree with L3. It is not flavoured water. He first said that the substance in container A is lemonade. L1's evidence is proof that it is not, because it is the container that smells like cool drink. L3 must listen..</i>	<i>Flavoured water has a gas in. The substance in container A has no gas in it.</i>		L4

A remarkable claim made by L3 is that the temperature of a room is warmer than the inside of a fridge because “You can change the temperature in a fridge if you want it to be colder. He also states that it is the coldness in the fridge that prevents food from getting rotten”. He justified his claim by also stating that flavoured water has a gas in and that the substance in container A has no gas in it.

Table 4.10 Group 1 learners co-constructing an argument on container A

Learner	Claim	Grounds	Counter claim	Grounds	Rebuttal	AL
<i>L3</i>	<i>The gas in a cool drink can also go away. I..a.. mean it disappears mean</i>	<i>I tasted a cool drink with no gas in an.. and it did not taste right.</i>				L4
<i>L4</i>	<i>I agree with L3 that a cool drink don't taste right if there is no gas in.</i>	<i>If you don't close the bottle then,, the gas escapes.</i>				L5

In table 4.10 L3 and L 4both agreed that the when a cool drink is left open, the gas will escape thus resulting in the cool drink not tasting right. They also came up with valid evidence to support each claim.

Table 4.11 Group 1 learners co-constructing an argument on container B

Learner	Claim	Grounds	Counter claim	Grounds	Rebuttal	AL
<i>L1</i>	<i>Container B is polluted water.</i>	<i>There is dirt in.</i>				<i>L2</i>
<i>L2</i>	<i>I agree with L1 because the water is polluted water.</i>	<i>The water is black and there is papers, sticks, leaves, and some sand in it.</i>				<i>L2</i>
<i>L4</i>	<i>I agree with L1 and L2. The water is polluted. Polluted water is not good for people. There's germs in ..in the water.</i>	<i>People get waterborne diseases like cholera and they can die.</i>				<i>L3</i>
<i>L3</i>	<i>L4's point is valid but I want to add that polluted water can also destroy the environment..</i>	<i>Acid rain lowers the oxygen level in the water which causes the fishes and other water creatures to die.</i>				<i>L4</i>
<i>L2</i>	<i>I agree with L3but the acid rain also destroy the plants that grow in the river.</i>	<i>Plants die in the river. There's no plants.</i>				<i>L5</i>

In Table 4.11 all the learners agreed that container B is polluted. They justified their claims by providing different evidence. What definitely stood out during the argumentation was that the learners were now more aware if other learners disagreed with their claims, or came up with counterclaims and even rebuttals, that it was not personalized. It was evident to see how these young learners listened attentively and not interrupt each other while making claims. The argumentation level of individual learners improved as to evaluate each one's contribution during the group discussion. The quality of their arguments was identified by probing the level of argumentation. This might be due to the fact that the language used by learners were clear and it could be easily analyzed

Group 2: Transcript 2:

The learners had to discuss a picture of a clean and polluted river and build their arguments around River A and B. It started with a simple discussion that resulted in them making claims and justifying it with evidence. There was one counterclaim but no rebuttals due to the nature of the activity. All the learners in Group 2 came to a common agreement that River A was clean while River B was polluted. They presented all types of grounds to justify their claims.

Table 4.12 Group 2 learners co-constructing an argument on river A

Learner	Claim	Grounds	Counter claim	Grounds	Rebuttal	AL
L1	<i>River A is clean</i>	<i>There is no trash in the river. The children pick up the dirt and clean the river.</i>				L2
L2	<i>The river is healthy.</i>	<i>There are fishes in the river and a man is catching fish. Children are swimming in the river. The scientist test the water to see if it is free of germs.</i>	<i>L3 I disagree with L2. The river can be polluted.</i>	<i>L3 The children swimming in the river can pollute it. Their feet can be dirty.</i>		L3
L3	<i>River A is not polluted, it is clean.</i>	<i>The people do not live near the river. The houses are very far from the river.</i>				L4
L5	<i>The water in river A is fresh and it is not filled with dirt.</i>	<i>There are also birds ...what do you call it now? near the river and also plants.. L3: It's called a flamingo.</i>				L5
L3	<i>The pesticides can't go in the river.</i>	<i>The farms are not near the river.</i>				L6
L4	<i>Factory waste can't pollute the river.</i>	<i>The factories are far from the river. The factory waste goes into tanks.</i>				L6

In Tables 4.12 the learners were actively involved in their collaborative group work. They listened to each other in their groups and consequently developed more thoughtful responses than would have otherwise been the case. It was evident at times that some learners played the role of a supporter, listener and challenger. What I liked most, was the fact that each learner made a different claim with regard to River A and provided valid evidence. They did not give one-word answers but expanded on it by giving well-constructed ideas. L2 claimed in Table 4.12 that: (1) there are fishes in the river, (2) a man is catching fish in the river (3) children are swimming in the river and (4) that scientist are testing the water to see if there are any germs in it. Whereas L3's counterclaim that river A is not clean because of the children's feet that might be dirty while swimming in the river can be seen as valid.

Table 4.13 Learners co-constructing arguments on river B

Learner	Claim	Grounds	Counter claim	Grounds	Rebuttal	(AL)
L3	<i>River B is polluted.</i>	<i>It is filled with dirt.</i>				L2
L5	<i>River B is unhealthy because people live next to the river.</i>	<i>People wash their clothes in the river. They use the river as a toilet.</i>				L3
L2	<i>The river is full of germs.</i>	<i>Factory waste runs in it.</i>				L4
L3.	<i>I agree with L2 because I can see that the fishes are dead.</i>	<i>Acid rain, yes.. it is acid rain that lowers the oxygen level in the water and this cause the fishes to die.</i>	<i>L1 I agree with L3 but it is also the germs in the river that kill people.</i>	<i>I have seen on television how the fishes have died in dirty rivers.</i>		L5
L1	<i>If you drink the water from a polluted river you can get sick.</i>	<i>There are germs in the water. You get cholera.</i>				L4
L4	<i>I can drink the water if there is no papers or dirt in river water . If it looks clean then I can drink from it.</i>	<i>There is no dirt in</i>	<i>L1: I disagree with L4. If you take out all the dirt, the water will still be polluted. Water look clean and then it is not..</i>	<i>Germs can't be seen with the naked eye. It is too small.</i>		L5

In Tables 4.13 the learners responses differed to a large extent from one another. Although they all agreed that river B is polluted, their vocabulary improved tremendously in the sense that they came up with different ideas. They were actively involved in their collaborative group work. They listened attentively to each other in their groups and therefore developed more thoughtful responses. The explanations given by the learners to justify their claims showed that their initial views had changed dramatically after teaching the intervention.

Table 4.14 Learners co-constructing arguments on river B

Learner	Claim	Grounds	Counter claim	Grounds	Rebuttal	(AL)
L2	<i>Pesticides goes into the water and pollutes it.</i>	<i>It kills the water animals because there is not enough oxygen for the animals..</i>				L6
L4	<i>I can drink the water if there is no papers or dirt in river water . If it looks clean then I can drink from it.</i>	<i>There is no dirt in.</i>	<i>L1: I disagree with L4. If you take out all the dirt, the water will still be polluted. Water look clean and then it is not..</i>	<i>Germs can't be seen with the naked eye. It is too small.</i>		L6
L2	<i>Pesticides goes into the water and pollutes it.</i>	<i>It kills the water animals because there is not enough oxygen for the animals..</i>				L6

In Tables 4.14 the learners answers showed that they developed a better understanding of polluted rivers and the way pollution move. They also realised that germs cannot be seen with the naked eye and that pesticides are also harmful to animals living in the water. All their claims were justified by valid evidence. The learners have now realised that water pollution can take place in many ways and not just through littering.

Group 3: Transcript 3a

This group had to do an experiment on how to clean polluted water for drinking. All apparatus were at their disposal, which they had to select. After reading a short story in a dialogical form, the learners then completed the worksheet individually and afterwards had to reach consensus in the group. The content of Table 4.15 below was extracted from their dialogical argumentation session.

Table 4.15 learners co-constructing arguments on a short story in dialogue form

Learner	Claim	Grounds	Counter claim	Grounds	Rebuttal	(AL)
<i>L1</i>	<i>The baby is sick.</i>	<i>He is crying.</i>				L2
<i>L5</i>	<i>I agree with L1. The baby is not feeling well.</i>	<i>He don't want to eat food.</i>				L3
<i>L2</i>	<i>The water has germs in.</i>	<i>A lady washed her baby's nappies in the river.</i>				L4
<i>L3.</i>	<i>The baby is dehydrated.</i>	<i>He is throwing up. He has diarrhoea.</i>				L5.
<i>L4</i>	<i>The baby can die.</i>	<i>The more he vomits. The weaker he will get. There ww..will be no water in his body.</i>				L6

An examination of the learners' comments in Table 4.15 above shows that one girl in the group played a leading role to get the group started. Some learners played the role of supporter, listener and challenger. An analysis of the content of the dialogue depicted in Table 4.15 shows the learners' claims or counterclaims to range between non-oppositional statements to those with one or more grounds but no rebuttal i.e. levels 0-1 of Toulmin's Argumentation Pattern (TAP). According to Erduran et al (2004), the more the grounds and rebuttals the higher the quality of the argument.

Indigenous Knowledge Systems (IKS)

Transcript 3b: Purifying polluted water in a container. Before doing the experiment learners seriously engaged in dialogue. It was quiet interesting to see how the learners discussed what apparatus to use for the experiment.

L1: We must purify the water, but what are we going to use?

L3: Let's use the top half of a plastic cool drink bottle.

L2: What about the bottom half?

L1: Why do we need the bottom half?

L3; We need it so that the filtered water can go in there.

L1: You are right.

L5: That's not all we need. We must also t..take the sand, big stones

L4: We also have to use the fine sand.

L5: There's different sand. What one must we use.

L1: The fine sand.

L3: You forgot about the white cloth. Oh... yes, you right.

L5: What about the white cloth that we must also use.

L3: After we filtered the water then we must filter it again through the white cloth . L1: Where is the water we must filter? Can we start now?

L3: Before we filter the water, we must first put the big stones in the container. Then the small stones and then the fine sand.

L5: Who is going to do what?

L2: I will write down who is doing what?

L3: That's right. Now each one of us will do something.

Table 4.16 Group 3 learners co-constructing arguments during an experiment on water pollution.

Learner	Claim	Grounds	Counter claim	Grounds	Rebuttal	(AL)
L4	<i>The water is polluted.</i>	<i>There is small pieces of dirt in it.</i>				L2
L5			<i>I don't think the water is dirty. It looks clean.</i>	<i>I don't see any dirt in the water.</i>		L3
L1	<i>I disagree with L5. The water looks murky.</i>	<i>Dirt can make clean water murky. When water is murky, it tell us there is dirt in.</i>				L3
L2			<i>I also agree with L1 but disagrees with L5. There's always germs in water.</i>	<i>Germs can't be seen with the naked eye. It can be clean on top, but the germs are too tiny to see. Polluted water can also has a smell.</i>		L5
L3	<i>Lets first filter the water by using a white cloth.</i>	<i>To catch tiny pieces of dirt on the cloth.</i>	.			L3
L3	<i>Why must we do that first? The main thing is that we need to filter the water.</i>	<i>So that the stones and sand collect the dirt before we filter it through the white cloth. The sand and stone will collect most of the dirt</i>				L5

In this experiment, (Table 4.16) the learners engaged in arguments with each other to resolve conflicting viewpoints. Although I was in the background, I did not interact with the learners. Whenever I noticed that the group was discussing a problem, I would move further away from the learners, but still within hearing distance to see how they solved the problem. The learners' came up with valid evidence for each claim made in convincing L3 that it is best to first filter the polluted water with stones and fine sand as to collect the bigger pollutants and then the white cloth to collect the tiny pieces of dirt that slipped through the filter. The explanations given by the learners to justify their claims showed that their initial views had changed dramatically after teaching the intervention.

Table 4.17 Group 3 learners co-constructing arguments during an experiment on water pollution

Learner	Claim	Grounds	Counter claim	Grounds	Rebuttal	(AL)
L2	<i>I agree with L3 and L1. It is important to filter the water. When we filter the water , I m..mean the polluted water then it is better to filter it first with the stones and sand.</i>	<i>To collect most of the dirt.</i>				L5
L5	<i>Yes, I agree with L2. After we filtered the water with the sand and stones then we will filter it with the white cloth.</i>	<i>To get the tiny pieces of dirt that slipped through the stones and sand.</i>				L5
L2	<i>Let's identify all the things that pollute the water before we filter it. Write it down.</i>	<i>It is sand, leaves, sticks, paper, button and a piece of cloth.</i>				L3
L2	<i>Do we all agree to filter the water with the stones and sand first. Now look carefully what stays behind.</i>	<i>Each one must identify it. The leaves, button, paper and cloth did not go through.</i>				L3
L5	<i>Yo! The water is now clean.</i>	<i>I don't see anything in the water now.</i>				L4

In Table 4.17 each claim made by the learners were justified with valid grounds and they respected each other's opinion. They were actively involved in their collaborative group work. They listened attentively to each other in their groups and therefore developed more thoughtful responses The explanations given by the learners to justify their claims showed that their initial views had changed dramatically after teaching the intervention. What I liked about this group was that they each came up with different views but reached a common understanding at the end. L2 played the leading role of an educator.

Table 4.18 Group 3 learners co-constructing arguments during an experiment on water pollution

Learner	Claim	Grounds	Counter claim	Grounds	Rebuttal	(AL)
L4.	<i>I agree with L5. Now we have to filter the water with the white cloth. We must filter the water.</i>	<i>To pick up the tiny pieces of dirt that slipped through. Yo.! look at the tiny black pieces of dirt on the cloth. I then thought the water is clean.</i>				L4
L1	<i>The water is still dirty.</i>	<i>Look! there is a piece of hair and I also see sand.</i>				L4
L2	<i>The water is now clean.</i>	<i>There are no more dirt in it. We filtered it.</i>	<i>L4 I disagree. There can still be germs in.</i>	<i>L4 Germs can't be seen with the naked eye.</i>		L5
L2	<i>Now we must boil the filtered water. Can I boil the water?</i>	<i>To kill the germs</i>				L3
L3	<i>Let's throw the filtered water in the kettle or a pot</i>	<i>L3:U can also make a fire and put the pot on the fire if there is no electricity</i>				L3

In table 4.18 the learners assessed their own arguments by reviewing their evidence. After the teaching intervention, they realized the importance of filtering the water by making valid claims supported by evidence. They also had a better understanding on how to go about cleaning polluted water.

Table 4.19 Group 3 learners co-constructing arguments during an experiment on water pollution

Learner	Claim	Grounds	Counter claim	Grounds	Rebuttal	(AL)
L3	<i>Throw a teaspoon of jik in the boiling water .</i>	<i>To kill tiny germs you cannot see with the naked eye.</i>				L4
L1	<i>Now we must close the pot.</i>	<i>To keep germs out.</i>				L4
L3	<i>Let's throw the filtered water in the kettle or a pot</i>	<i>L3:U can also make a fire and put the pot on the fire if there is no electricity</i>				L3
L3	<i>Throw a teaspoon of jik in the boiling water .</i>	<i>To kill tiny germs you cannot see with the naked eye.</i>				L4
L1	<i>Now we must close the pot.</i>	<i>To keep germs out.</i>				L4

In Table 4.19 the learners responses improved once again. There was a good understanding throughout the experiment discussion. It was so amazing to see how these young learners carried out a practical experiment through engaging in dialogue in the group which led to making claims, counterclaims and providing it with evidence.

Group 4: This group looked at a picture indicating how the wastage of water can be reduced with appropriate conservation measures. After being engaged in a class dialogue, they made the statements depicted in Table 4.20 below.

Table 4.20 Group 4 learners' ideas about how to reduce the wastage of water in the home

Learner	Claim	Grounds	Counter claim	Grounds	Rebuttal	(AL)
<i>L3</i>	<i>Fix leaking taps.</i>	<i>Put a bucket under a leaking tap and measure how much fresh water has been wasted.</i>				<i>L2</i>
<i>L5</i>	<i>I agree with L3 because many water is wasted when taps leak.</i>	<i>Our water account was high because my daddy did not wanted to fix the dripping tap. After he fixed the tap, the water account is no more so high.</i>				<i>L3</i>
<i>L2</i>	<i>I agree with L3 and L5. Leaking taps cost money and waste water.</i>	<i>If my daddy wants to know if taps are leaking in the house then he checks the water meter. He tells us not to open the taps in the house. If the numbers on the meter is moving then there is a leaking tap in the house.</i>				<i>L3</i>
<i>L4</i>	<i>Drink out of a cup.</i>	<i>You use a little water.</i>				<i>L3</i>

In Table 4.20 the learners answers showed that their initial views had changed from the pre-to the pos-testing. The grounds they produced for justifying their claims were valid. There was however no counterclaims. The learners were aware of many ways how water are being wasted and what measures to put in place to stop water wastage.

Table 4.21 Group 4 learners' ideas about how to reduce the wastage of water in the home.

Learner	Claim	Grounds	Counter Claim	Grounds	Rebuttal	(AL)
L3			<i>I disagree with L4. Drinking water out of a cup or a glass is still wasting it and not saving water.</i>	<i>People make the cup or glass full and only drink a little sip of water. Then they throw the other clean water down the drain.</i>		L3
L5	<i>I agree with L3. The best is to keep water in a bottle in the fridge.</i>	<i>When you thirsty you drink a little out of the bottle and put it back in the fridge. This is how you can save water.</i>				L4
L2	<i>I also agree with L3 and L5. Drinking out of a cup can save a little water .</i>	<i>If you drink out of a cup or glass and throw the rest of the water on a plant or flower, then you save a lot water.</i>				L5

In Table 4.21 it is clear that the learners answers showed that their initial views had changed from the pre-to the post-testing. The grounds they produced for justifying their claims and counterclaims, was valid. However there was no rebuttals. Nevertheless, they have not yet mastered the art of formulating rebuttals. This is understandable judging from the age of the learners. All they seemed to be able to do is to make simple arguments and to provide some grounds for their claims and counterclaims.

Table 4.22 Group 4 learners’ ideas about how to reduce the wastage of water in the home.

Learner	Claim	Grounds	Counter claim	Grounds	Rebuttal	(AL)
<i>L2</i>	<i>Rinse fruit and vegetables in a bowl of water. Do not rinse it under a running tap</i>	<i>Measure the water wasted under a running tap.</i>				<i>L2</i>
<i>L1</i>	<i>I agree with L2 but he can still save the vegetable water.</i>	<i>He can use it to water the garden or plants.</i>				<i>L3</i>
<i>L1</i>	<i>Take a shower instead of a bath.</i>	<i>Use less water if you shower.</i>				<i>L3</i>

In Table 4.22 the learners seemed to have known how to support their claims with valid grounds. After the intervention the learners had an improved understanding of reducing the wastage of water. Although there is no counter claims, learners came up with different viewpoints each.

Table 4.23 Group 4 learners' ideas about how to reduce the wastage of water in the home

Learner	Claim	Grounds	Counter Claim	Grounds	Rebuttal	(AL)
L3			<i>I disagree with L1 and L4. You waste water if you shower very long.</i>	<i>My brother showers longer than thirty minutes and then my I disagree with L1 and L4. You waste water if you shower very long. mom is angry with him. She says he waste water.</i>		L3
L2	<i>I agree with your mom. She is right. He don't have to shower so long.</i>	<i>If he showers for five minutes he will save a lot of water.</i>				L4
L3	<i>I think you right. Taking a shower can save water.</i>	<i>Only if you take a quick shower.</i>				L4
L2	<i>S..so if you are going to shower long, I think it is best to take a bath.</i>	<i>You save water.</i>				L5
L5	<i>You can save water by collecting rain water.</i>	<i>The w..water can be used to water the garden,</i>				L4
L1	<i>You are right. I agree with you</i>					L5

Table 4.24 Group 4 learners' ideas about how to reduce the wastage of water in the home

Learner	Claim	Grounds	Counter claim	Grounds	Rebuttal	(AL)
<i>L5</i>	<i>You can save water by collecting rain water.</i>	<i>The w..water can be used to water the garden,</i>				L4
<i>L1</i>	<i>You are right. I agree with you</i>	<i>But you can also use the same water to wash clothes.</i>				L5

In Table 4.23-4.24 all the learners were actively engaged in classroom dialogues, which often resulted in arguments where learners challenged each other's claims by providing evidence. For example, L3 disagreed with L4 with regard to his water saving measures of drinking water out of a cup. He contended that by drinking water out of a cup is not enough evidence to say that it is water saving measure. He further mentioned that drinking water out of a cup or glass and throwing the left over water down the drain is wastage of water. This motivated the other learners to get involved. L5 and L2 also agreed with L3. L5 indicated that the best way to save water is to keep a bottle of water in the fridge and drink what you need and put it back in the fridge. Whereas L2 stated that drinking water out of a cup will only save water if the leftover is used to wet plants or flowers. L3's counterclaim with regard to saving water when you shower is valid especially if one showers for a long time. The transcript depicted in Table 4.25 is part of a focus group interview which I found so interesting.

Table 4.25 Group 4 learners' discussion session on water conservation

Learner	Claim	Grounds	Counter Claim	Grounds	Rebuttal	(AL)
L1	<i>Rain water is safe to drink.</i>	<i>It is not polluted. There is no dirt in.</i>				L2
L2			<i>I disagree with L1 because rainwater is not safe to drink. It is polluted.</i>	<i>Smoke pollutes the sky. The smoke of factories and cars have dangerous chemicals in. When it rains the water mixes with the smoke and cause acid rain. This lowers the oxygen level in the water and cause the fishes to die.</i>		L4
L3	<i>Y..yes, nobody died from rain water yet, but it...it is not clean. It is polluted, by smoke and this causes acid rain.</i>	<i>Acid rain kill water animals living in it.</i>				L5

In Table 4.25 the learners made quite interesting claims supported with valid grounds. L1 mentioned that rain water is safe to drink, because it is not polluted, whereas L2 disagreed and stated that rain water is polluted as a result of smoke polluting the air and that this causes acid rain which is harmful to fishes.

Table 4.26 Group 4 learners' discussion session on water conservation

Learner	Claim	Grounds	Counter Claim	Grounds	Rebuttal	(AL)
L3			<i>L2 claims that when smoke and rain mixes it causes acid rain. S..so if people drink the polluted rain water it can make them sick .</i>	<i>If fishes die of it, it will also affect people. They can get sick.</i>		L5
L1	<i>L3 said that people can get sick from acid rain. What proof do you have.</i>	<i>I don't have any grounds, but it may happen over time.</i>				L2
L3					<i>Miss always say, that science change over time. S..so if acid rain does not make people sick now, it might make people sick in the future.</i>	L6

What an amazing interview it was. Before the post-test I would never have dreamt that young learners would be able to argue like this, but they demonstrated that their ability to argue in a coherent way. In fact, I had my doubt if grade three learners would be motivated to speak openly and express their personal views in class judging from the traditional society in which most of the learners lived in.

They made claims, counterclaims, justified it with evidence, and sometimes even made rebuttals (see Table 4.26). What also highlighted their argumentation and made it comprehensible was the vocabulary they loved using. The more they argued, the more their vocabulary improved tremendously. Their arguments were consistent and logic and they uphold their dialogue throughout.

It was evident how they would listen attentively to claims and review the grounds before responding or making counter claims or even rebuttals. They challenged each other's arguments and saw it as a new focal point. I always tell the learners during science lessons that science changes over time and that what is known as science today may not be known as science tomorrow. However, not for once did I think that a learner (L3) would use this as a rebuttal. This really caught me off guard and I felt so proud of these young ones. They however knew that a good argument needed to be justified with evidence. Argumentation improved their content knowledge on the topic.

4.8 Research Question 3

Are the learners' understanding of water pollution related to their age, gender and social economic background?

In this study, the learners' conceptions of the causes and effects of water pollution are not significantly influenced by gender or age. An analysis of the responses of the WPQ shows that gender has not affected the understanding of water pollution. From the four groups in the study three groups had girls who played the leading role whereas one group had two boys who were in the lead. Although it was evident in the study that the girls were competing with each other as well as with the boys in terms of making claims and justifying it. Therefore, Swann's claim that (1992) that girls avoid competitive behaviour has not been confirmed in this study.

However, the study has confirmed his claim that there is no difference between boys' and girls' argumentation levels. It was interesting to see how two boys in the same group got involved in an intense argument without reaching consensus. As they raised their voices, I moved closer to them to see how I could help them argue in a more coherent way than they were doing. Below is an excerpt of their argument:

L2: “Put down your pencil. Everyone in the group must still make their claim and give evidence about container A. You are taking too long to explain.

L5: I’m thinking and you are rushing me. I’m not putting my pencil down because I am not yet done. I must still put the thermometer in container A and B to see what substance is colder so that I can write in my evidence on my page. You just want to dominate the group.”

Based on the above, I politely asked the two learners not to rush each other but to listen to each other’s claims and then respond accordingly. Soon afterwards, I moved away from the group so that my presence would not affect the outcome of their reasoning, but observed them from a hearing distance to see how they reacted. It was amazing to see from a distance how a girl intervened and how the problem was solved and both boys finally reached an agreement. Here is an excerpt on this.

L3: I listened to both L2 and L5. I agree with L5 because you are rushing him and he is still busy and you shouted at him.

L5: You a... are right, he is rushing me and I was still thinking and I don’t like it if children shout at me. He just want to boss us around. Teacher did not choose him to be the leader of the group. She said we are all the leaders.

L3: As a group we must work together and b..be patient. Nobody in the group wanted to start and that is why L2 started. So he was right. Some children will take longer and other children will work faster. Do you agree with me L2?

L2: Yes L3 I agree with you. I am sorry and it will not ha.. happen again. I’m really sorry. L5: Thank you L2.

L3: Can we go on with our work now? L2 and L5: (smiling) of course!

L3: There is still other children that must make their claims. We must work faster now before our time is up.” The whole group is happy now and full of smiles.

Although L3 was not the leader in the group she was however confident to intervene so that the group could solve the problem and complete their task. It is possible that L2’s behaviour dampened the other quiet learners’ spirit in the group which resulted in them not having the courage to participate and reason. L3 did not just come to L5’s aid but also her approach appealed to everyone in the group.

The case related above contradicts the Piagetian notion that cognitive development is related only to age of the children because experience also counts as well. Also my experience in the study contradicts those of other scholars (e.g. Kuhn et al., 1998; Mercer et al., 1999., Samarapungavan, 1992; Sodian et al., 1991) that young children are not capable of constructing arguments. Based on this study, the degree to which young children can engage in dialogical argumentation cannot be linked to age alone. It seems that other socio-economic factors such as opportunities to be engaged in, or participate in debates and dialogues on various controversial issues, classroom discourses and group discussions as has been done in this study, can enhance learners' ability to debate in a coherent way.

These findings are comparable to earlier findings in the area. For example, Ogunniyi (1999) found that certain demographic factors such as age, gender and career interest influenced grade 7-9 learners' performance on various scientific concepts tested. He found that young learners outperformed older ones. Based on the findings of this study I do agree with him, seeing that the learners' everyday experience, as well as gaining some scientific ideas at school must have contributed to the learners' understanding of water pollution as well as the their worldviews in general. The belief systems of different cultures are not the same. It was evident in the study how the two worldviews linked up with each other regarding water pollution.

The scientific view was obvious when the learners in the E group mentioned in the post-test that water could be purified by putting chemicals in it so that it can be re-used again. One learner also mentioned that their pool water is purified by the use of a chemical known as Blue 52. In purifying water, the IKS way, learners indicated that after filtering the water, it needs to be boiled, then a spoon of bleach needs to be added to destroy tiny germs that is not visible.

4.9 Environmental attitudes

Moseley (2000) argues that learners are environmentally literate when they demonstrate sensitivity towards the environment or show awareness about the environmental changes taking place. In his study over 94% of the learners were aware of environmental issues and had conceptions of water pollution, air pollution and the effect that these could have on people, animals, plants and the environment as a whole. In this study, all the learners displayed a real concern for the environment by giving positive views on how to save the environment as well as conserve water.

In fact, most of the learners were worried with regard to what harmful effect pesticides could have on clean water and our health. 75% of the learners indicated that they liked reading science books while 62% indicated that they watched many science programs on television with their parents dealing with environmental issues. Further, 36% of the learners said that their parents also bought environmental videos for them to watch at home and 6% indicated that they had internet connection at home and watched environmental issues.

All the learners indicated that they liked to log on to the science program Inkatha Kids at school. 34% mentioned that they visited the library and liked to take out science books. One learner indicated that her mother usually filed all science related articles cut from newspapers and magazines. Whenever she needed information on a topic, she would just go to the science file at home for any information. The majority of learners showed a positive attitude towards environmental issues like clean water, air, people, animals, plants and planet earth. They were also aware what effect polluted water and air could have on the environment, people, animals, plants and planet earth. They also mentioned that they were prepared to help keep the rivers or streams clean in their community by picking up the dirt in the rivers or streams.

4.10 Environmental behaviour

The findings of this study also indicate that learners who were more exposed to environmental resources like reading science related books, magazines, watching environmental programmes on television with their parents, logging on to the computer or internet showed adequate environmental behaviour. Kollmuss & Agyeman (2002) argue that children who get environmental knowledge from school will have the slightest environmental behaviour and knowledge.

This is not necessarily true because if lessons are planned in such a manner where learners are given the opportunity to bring their own cultural knowledge (IKS) to the classroom and integrate it with the scientific knowledge through dialogical argumentation, and by means of being exposed to a variety of hands on science activities will surely improve their environmental behaviour. Studies have shown that increasing individual' environmental knowledge may have positive attitudes and more responsible environmental behaviours. Leeming et al. (1997) have argued that students who participate in environmental activities at school will have a positive effect towards the environment.

Also Roth (1992) and Wilke (1995) claim that environmental behaviour of people reveal their environmental knowledge with regard to responsible environmental behaviours. The findings of this study has also shown that if the topics treated at school are related to learners' experiences and indigenous knowledge and practices as it is with water consider in this study, their interest in environmental issues could be greatly enhanced.

4.11 Social economic background

The study revealed that socio-economic background is an important factor regarding environmental awareness. For that reason, it is safe to assume that the educational background of parents is likely to impact on children's knowledge of the environment and consequently their behaviour to that environment. The current study has showed that learners who had more educated parents were able to demonstrate a better understanding of environmental issues than those whose parents were not very educated. Makki et al. (2003) claim that educated parents might supply their children with numerous environmental learning resources. Another factor might be that educated parents will share their knowledge with their children as they sit around table to discuss local and global environmental matters and as they watch environmental programmes on television together. These ideas are also shared by other researchers (e.g. Chu et al. 2007; Musser and Diamond, 1999)

4.12 Summary

From the findings of this study the following conclusions have been reached:

- The grade three learners involved in this study demonstrated convincingly the ability to argue in a comprehensive manner.
- They were able to demonstrate the ability to make claims, counterclaims and to provide valid grounds (evidence, warrants, and backings) and even sometimes to make rebuttals to counter such claims or counterclaims.
- Experimental Group (E) learners exposed to Dialogical Argumentation Instructional Model (DAIM) outperformed by a wide margin their understanding of the importance of water and causes of water pollution than their counterparts Control Group (C) exposed to traditional teaching.

- Both groups E and C groups demonstrated a higher understanding of the connection between water pollution and water-borne diseases at the post-test than at the pre-test. However, even in this regard the latter showed a greater understanding than the latter.
- An examination of cloze test scores shows that E group possessed a higher level of language acquisition needed to make valid arguments about the importance of water and water pollution (probably because of DAIM) than C group.
- E group learners showed a higher awareness about measures needed for water conservation than C group learners did.
- E group learners showed a higher understanding of and appreciation for the IKS-based methods of water conservation at the post-test than was the case of the C group.
- E group learners showed a higher sensitivity to environmental impact of water pollution than their counterparts did in the control group.

CHAPTER 5

CONCLUSIONS, IMPLICATIONS, AND RECOMMENDATIONS

5.1 Overview

The nature of science is an important and vital part of any science course intended at developing scientific knowledgeable individuals. Science educators working in the area of scientific literacy support the need for learners to study the nature of Science (NOS) dealing with socio-scientific issues that impinge on their daily lives. The argument is that people need to become aware of how knowledge of the application of science is critical to survival in a world dominated by scientific and technological activities (Akerson, Abd-El-Khalich & Lederman 2000; Lederman *et al.*, 1998; Ogunniyi, 1983, 2004). The question is, “How does the understanding of the NOS lead one to become scientifically literate?” One may know how science works and yet adopts a life style contrary to that knowledge. An individual may be well aware of the harm that cigarette smoking could cause to his/her health and yet smoke despite such awareness. In the same vein, Walker and Zeidler (2007) have wondered about the use of students being able to articulate the significance of NOS if that understanding is not useful for them to assess and make valid decisions about socio-scientific issues.

The study deployed an argumentation-based instruction because it was considered to be a useful way to provide the necessary opportunity for grade three learners to express their views freely without intimidation about an important subject matter namely, water which they encountered daily whether at home or at school. Despite the fact that various studies (Bell & Lederman, 2003; Sadler, Chambers, & Zeidler, 2002; Sadler & Zeidler, 2005a; Zeidler et al., 2002) have tried to detect the role of knowledge in decision-making on Social Scientific issues (SSI), very little progress has been made in developing and assessing NOS-SSI learning that can be used by teachers in the science class. The purpose of this study was to document grade three learners’ understanding of water and how to prevent water pollution through dialogical argumentation in order to inform curriculum development efforts and instructional practices in schools.

In pursuance of this objective, qualitative and quantitative data about learners' conceptions of water and water pollution were collected, analyzed and discussed. The results obtained from the study were then summarized at the end of the last chapter. The purpose of this concluding chapter is to explore the implications of the findings for curriculum development and instructional practice.

5.2 Major findings

Analysis of the questionnaire indicates in the pre-test that both the control and experimental groups generally lacked an adequate knowledge concerning certain aspects about water and water pollution. For instance, the learners were not well aware of environmental issues relating to water and consequences water pollution. However, a number of misconceptions concerning water and water pollution were also depicted in the pre-test and were cleared up during the intervention process: According to Mohapatra and Bhadauria (2009:74) "Misconceptions is one of the significant factors which affect learning." Some of the misconceptions concerning water and water pollution held by the learners at the pre-test include the following:

- Water contains no germs after the dirt has been removed.
- Sand is not seen as a water pollutant.
- Water is white.
- Water is see through.
- There was a lack of scientific reasoning.
- They thought that water is only polluted through dirt.

Learners usually develop misconceptions as a result of their own interpretations or some contradictory explanations in school or out school environments in early periods of their school years (Wandersee et al., 1994; Cardack, 2009). Misconceptions not detected continue for long years and cause major barriers in understanding science education. Before the intervention the learners were not aware that pollution moves from one place to another for example, when it rains the pesticides are washed into the soil and then into the rivers. They did not know that smoke in the atmosphere undergoes a chemical change when it mixes with rain and that it results in acid rain, which lowers the oxygen level in rivers, as well as affecting biodiversity and that human health can be in danger if waterborne diseases are contracted.

That germs cannot be seen with the naked eye and that polluted water could be cleaned through the use of indigenous methods to make it drinkable. Before the intervention the learners did not realize that water pollution is a global phenomenon. Ogunniyi and Hewson (2008:112) points out that:

With the increased global awareness of the negative impact of scientific, technological and industrial activities on the environment and copious examples of sustainable practices existing in many an indigenous community, the new South African science curriculum statement has called on science teachers to integrate school science with the Indigenous Knowledge Systems (IKS). As shown in the last chapter the learners in both E and C groups increased in their understanding of the importance of water and water pollution from the pre-to the post-test. However, the E group significantly outperformed the C group after they had been exposed to the dialogical argumentation instructional model (DAIM).

The learners especially in the E group were able to co-construct different views about water and water pollution depending on the context. According to the Contiguity theory (CAT) the arousal context tend to motivate people to change their viewpoints so as to adapt to the new situation they find themselves (Ogunniyi, 2007a). In addition, because of their exposure to DAIM the E group learners (compared to the C group learners) were able to demonstrate among others, the following characteristics:

- Their listening skills improved considerably, seeing that they were now capable to connect the discourses with specific purposes in mind.
- They developed a better understanding of the global importance of water and water pollution.
- They showed substantial understanding of how acid rain is formed, and how it could have harmful effects on biodiversity.
- They became aware of the damaging effects of how factory waste products and pesticides could have damaging effects on river systems and the ecosystem as a whole.
- They developed a better understanding of the link between polluted water and waterborne diseases.

An analysis of transcripts indicates that young children in grade 3 are capable of co-constructing arguments through collaborative interaction as also stated by (Keogh, Naylor, Downing 2003). The substantial improvement of the E group learners can be directly accredited to the quality of the new learning environment of dialogical argumentation through cognitive harmonization (see Fig. 3.1) in terms of small group collaborative learning; co-constructing arguments based on the phenomena under study; intra- and inter-group discussion leading to coherent arguments; development of leadership qualities as learners take up leadership roles; opportunities to reach consensus and harmonization of ideas during whole class discussion. The children were well-focused, task oriented and listened attentively to the claims made by their fellow learners before responding. This resulted in the learners' co-construction of arguments of a high quality.

The fact that these learners moved beyond my expectations during argumentation was incredible, for example, one learner mentioned that if acid rain can cause fishes to die, then it could also affect people's health. The activities designed were an effective stimulus for generating collaborative ideas. These activities used to enhance argumentation skills as they developed their reasoning in different contexts. It also helped the children to understand and develop difficult science concepts, and to understand the nature and development of scientific knowledge as well as communication skills (Duschl and Osborne 2002). The various activities in the classroom did not involve any direct tuition on my part.

All I did was to provide the opportunity where the learners were able to inquire as scientists and as independent learners (Hall and Sampson 2009). As a result of this approach the learners could interpret the data they got from an investigation. They worked collaboratively, made their own decisions and reached a common agreement. There was significant improvement in their language ability and the vocabulary used. Age and gender did not seem to affect the scientific ideas and alternate ideas of the learners about water and water pollution. From the foregoing, it appeared that creating a conducive learning environment for learners could assist them to develop necessary knowledge and attitudes critical to environmental conservation particularly in relation to water conservation and safety. The increased awareness among the learners about the importance of water is indicative of the potential of dialogical argumentation instruction for improving the scientific literacy of learners as well as enhancing their positive behaviour towards the environment.

Bonnet (2007: 707) argues that “our present environmental predicament not only provides an exciting opportunity to re-focus education on the issue of human relationships to nature, but also requires the exploration of this issue for its long-term resolution.” Hsu (2004) adds that to conserve the environment, people must be made aware of the environmental problems, so that environmental sensitivity will contribute towards a sustainable environment. Environmental education should not just be based on emotional aspects, but should be sustained by a good understanding of the fundamental mechanisms, which lie beneath the appearance of environmental problems (Starvridou and Marinopoulos, 2001).Several studies (Bell & Lederman, 2003; Sadler & Zeidler, 2004; Zeidler et al., 2002) have also indicated that the affective, emotional, and individual sphere of knowledge is vital in decision-making on SSI. The findings of this study have implications for various aspects of the education system. These implications together with the recommendations on how they could be addressed, will be considered in the following section.

5.3 Implications for recommendations

5.3.1 Implications for the teaching and learning process

The findings of this study join a plethora of others (e.g. Mohapatra, and Bhadauria, 2009, Stavridou & Marinopoulos, 2001, Chapman and Sharma, 2006, Yurttas and Sulum, 2010, Oztaz and Kalipci, 2009) in confirming that alternate ideas on water and water pollution are held by many learners and if not identified will have long lasting effects on them which will be resistant to change. The call to integrate school science with Indigenous Knowledge Systems (IKS) is emphasized in the Revised South African Curriculum Statement (2002).

The motive for integrating science with IKS is to sustain environmental sustainability in non-western societies (Hewson, 1988; Odora-Hoppers, 2002; Ogunniyi, 1988, 2004). This has cultural, ethical and historical implications and the type of curriculum to be developed. The results of the present study show the challenges learners have to face in relating their indigenous knowledge with school science (e.g. Aikenhead and Jegede, 1999; Ogunniyi et al., 1995). Learning Outcome 3 (LO3) of the Revised Curriculum 2005 for the Natural sciences, expects learners to demonstrate an understanding between science and the environment (DOE, 2002), as well as to integrate and recognize the different worldviews other than science.

Science and IKS are based on two different paradigms and can be of great challenge to teachers and learners. Ogunniyi (2004) has shown how the contiguity theory which he proposed could provide a useful platform to integrate both systems of thought. Teaching IKS and science separately, without acknowledging their everyday knowledge and alternate ideas, will do injustice to learners. In my opinion, teachers teaching in multicultural schools need to appreciate the traditional knowledge of their learners and incorporate it with science in the classroom. This prior knowledge can be utilized to decide on what content to be thought and how it will be taught, so that learners can make the connection with science and IKS.

Unless this is done, the policy of inclusive education will lead to curriculum failure. Studies by various scholars shown the positive effects of argumentation in enhancing teachers and learners' understanding of the nature of science and socio-scientific issues (e.g. Erduran et al, 2004; Osborne et al, 2004a, Simon et al, 2006; Ogunniyi, 2006a, 2006b, 2007a;2 Ogunniyi & Hewson, 2008). Teaching ought to help students comprehend the global aspect of water pollution as well as how pollutants can spread from one place to another, particularly through human activities. The findings of this study has shown that by introducing learners to environmental issues like water and water pollution through the appropriate instructional strategies right at the junior primary school level they could begin to grasp the importance of socio-scientific issues.

The implications for curriculum development and instructional practice seem obvious namely that learning materials should consist of science concepts relevant to the daily lives of learners. Gillies, (2003) and Herrenkohl et al. (1999) have emphasized that children need to be trained purposefully. They need explicit guidance to develop the skills of argumentation in order to challenge their peers and to engaged in urbane discussion. If teachers use creative instructional approaches (e.g. dialogical argumentation instruction considered in this study) to expose their learners to socio-scientific issues the learners in turn would be able develop necessary knowledge, skills and attitudes to cope with diverse environmental challenges they face in their daily lives. Dialogical argumentation instruction has been in various studies to guide children in how to work collaboratively in a group, to co-construct ideas and to reach meaningful decisions on various socio-scientific issues (Mercer, 2000).

Also if teachers provide children with activities where scientific evidence is discussed in collaboration within their peer group through the use of evidence and argumentation skills, their scientific reasoning skills is likely to be enhanced. It is not surprising that there are still many science classes in the primary schools that are characterized by the chalk-and-talk teaching despite the call by the Department of Education to adopt new instructional strategies compatible with the new environmentally focused curriculum. Also, when a single experiment is done, by only the teacher, learners are deprived of valuable science inquiry. Sustaining the environment in my view is just as important as Mathematics and Literacy in the young classes. Yilmaz, (2004:1544-1545) claims that “Using student centred teaching methods in science courses may help students to better discuss scientific concepts related to the environmental issues from many perspectives and increase students’ awareness of those issues.

This study provides evidence of the alternative conceptions that learners have with regard to water and water pollution. Studies have shown (Wandersee et al., 1994; Cardack, 2009), as mentioned earlier, that misconceptions not addressed in science classes would persist in the minds of children for a long time. Chu et al (2007) also point out that learners should be exposed to a range of environmental education resources and strategies in order to develop their environmental literacy. This according to them would promote learners’ conceptual understanding.

The integrated curriculum for young children should involve story telling about environmental issues affecting society and the environmental awareness of the interrelationship between water, people, animals, food chains, and water pollution. Furthermore, the curriculum needs to be more flexible to permit for differences in teaching strategies and thereby influence children’s environmental literacy that cannot be achieved in the classroom. This can be done through various teaching strategies and materials, such as field trips, engaging in newspapers, magazines and television programmes on water pollution that is more effective for young children.

5.3.2 Implications and recommendations for classroom practice

The results of the study reveal that some of the alternate conceptions that were found among grade three learners could be remedied through argumentation and discursive classroom discourses. Orr (1994) supports the fact that teachers need to partake in new pedagogical thoughts of environmental education with the conservative practice of curriculum, policy and education. He also mentioned that teachers need opportunities to develop their theoretically informed reflections, in order to provide insight into their pedagogical knowledge. To deal with the above concern the points mentioned in the section that follows below are worthy of close consideration.

5.4 Prior knowledge

It is of utmost importance that teachers need to uncover the learners existing ideas by interacting with them. In about three decades of teaching elementary science I have found that learners' level of engagement improves much easier with their peers when they relate the use of everyday knowledge in science classes. I have also found that tests are not the only way to find out about the issues that learners struggle with. I have come to the conclusion that group discussions are very useful in providing information on the existing knowledge on a topic and how they relate to their thinking with each other and the learning materials given to them. The findings of the study has not only corroborated Millar and Murdoch's (2002) claim but helped to confirm my experience of teaching science to children. For this reason, it seems imperative to start from where the learners are before taking them any further in their adventure in science.

5.5 Teaching strategies

According to Walker and Zeidler (2007:1404), "An increased understanding of the scientific content knowledge involved in the controversy would potentially allow students to be more critical of evidence and effectively utilize that evidence in the decision-making and debate process. They also indicate that most of the students who took part in their study as well as other students had little experience engaging in argument in most science classes and that that students must get intense training in preparing them how to engage in debate activities. The results of the pre-test reveal that the learners in this study found it extremely difficult to engage in discussion and co-construct arguments.

However, after thorough coaching in argumentation skills they were able to demonstrate higher thinking skills by supporting their claims and counterclaims with valid grounds and even sometimes mobilize rebuttals against a particular claim or counter claim and supporting ground. The study showed that that the learners encouraged each other to justify their claims with valid grounds. Likewise, the level of argumentation was more sophisticated than was the case before they were exposed to the intervention.

Teaching learners to argue at an early stage appears to enhance their thinking skills- a process skill envisaged in the new curriculum. It is essential that argumentation skills be taught early on given that co-constructing arguments within group discussions for older children has limited outcomes (Ratcliffe & Grace, 2003). Therefore, teachers need to provide learning opportunities so that the correct scientific explanation be taught to learners. Dreyfus et al (1990:559) have also claimed that “when students are actively building their own knowledge, the direction, nature and scope of the intellectual activity cannot be entirely predicted or controlled. For that reason teachers need to plan their lessons in such a way that would accommodate the expected as well as the unexpected responses from the learners. Activities should include observations of group experiments, investigations, discussions leading to arguments.

The activities designed must be an effective stimulus for generating collaborative ideas. It must also require learners to make decisions individually, in groups, through explaining their ideas and justify their claims to each other. Such activities can be use to enhance argumentation skills as they develop their reasoning in a different context on water and water pollution. Moreover it will help the children to understand and develop difficult science concepts, and understand the nature and development of scientific knowledge, and develop their communication skills (Duschl and Osborne 2002). Exposing students to discursive activities in the science classroom, cannot be more emphasized to improve science literacy (Walker and Zeidler 2007) .

One of the benefits shown by the findings of the study is that activities do not have to involve direct tuition from the teacher but need to provide an opportunity where the children inquire as scientists and become independent learners (Hall and Sampson 2009). It is also important that when teaching concepts, that the teacher starts from the known to the unknown. In this way learners can relate to a given topic e.g. water and water pollution. Also that concepts need to be taught in a sequence. Before discussing water pollution as such, the importance of water needs to be addressed first so that there can be a relationship between the different concepts taught.

Starting with water pollution in their immediate surroundings is essential before moving on to other types of water pollution for example, acid rain, pesticides and household sewage. It is evident from the findings of this study that if teachers provide children with activities where scientific evidence is discussed in collaboration within their peer group through the use of evidence and argumentation skills, their scientific reasoning skills is likely be enhanced.

5.6 Language

The learners' response to the Water Pollution Questionnaire (WPQ) as well as co-constructing arguments in their groups indicate the importance of language in the thinking process. The study reveals, that the more the learners engaged in argumentation, the more their confidence developed and their language ability improved. Allowing learners the opportunity to freely engage in collaborative talk is another way of exposing them to new science vocabulary (Dawes, 2004).

If language is not taught to them, they will find it severely difficult to engage in collaborative talk, asking questions, predicting, explaining, speaking clearly, reasoning by making claims and providing grounds. As a result of DAIM the claims made by the learners were clearer and the vocabulary they used was richer than was the case before the intervention. In their group discussions, they exchanged ideas with each other confidently and improved their conceptual understanding about water and water pollution quite substantially.

5.7 Culture and the Science in the classroom

The study exposed the learners to the different ways by which their respective communities had preserved water over hundreds of years. As they carried out their individual investigations they came up with a vast amount of new ideas which far beyond their wildest imagination. The study seemed to have opened the learners' eyes to knowledge and cultural practices for conserving water, which were, not documented in their textbooks.

It is hoped that the findings of this study could add to the research in this area and help teachers to understand traditional ideas on water, and water purification that could be used in the classroom. However before teachers can assist their learners integrate science and IKS-based materials they must have sufficient understanding of the two thought systems and how they can be linked in the teaching-learning process (Newton, Driver and Osborne, 1999). This will result in teachers moving away from the notion that existing ideas be replaced with scientific ideas.

5.8 Implication for curriculum development

The findings of this study have numerous implications for science education. The science curriculum needs to adopt suitable activities and opportunities to sustain pedagogical approaches in that:

1. Dialogical argumentation appears to stimulate a learning environment which enable learners to actively participate in classroom activities.
2. Teachers and learners co-construct arguments in understanding the content knowledge on socio-scientific issues.
3. Dialogical argumentation provides opportunities where learners can make claims, counterclaims and provide grounds.
4. It has led to an argumentation-based pedagogical model that may enhance teaching and learning of science as well as IKS.
5. It appears to enhance cognitive harmonization in school science classes.
6. It seems to enhance the teacher's ability to reflect on pedagogical matters.
7. Collaborative interaction is effective during small group discussions.
8. Learners are able to develop high level of argumentation skills.
9. It helps to broaden the validity of scientific knowledge, skills and behaviours needed to assess the soundness of scientific knowledge.

According to Ogunniyi (1986, 1988) the daily experiences of learner's must relate to science, by using familiar contexts, with the learner. Multicultural classrooms could provide a forum where different experiences can be undertaken. However, without the development of teacher training programmes for teachers that concentrate on the pedagogical techniques for dealing with socio-scientific issues they are unlikely to deploy such instructional strategies in their classrooms. Walker and Zeidler (2007:1405) suggest that "Strategies similar to socio-scientific issues are valuable in that it allows teachers to reveal and become familiar with epistemological factors of learners' reasoning including possible scientific misconceptions, moral reasoning, the ability to interpret and evaluate data, and fallacious reasoning.

A variety of scientific concepts and especially those dealing with socio-scientific issues in the Foundation Phase classes and higher up is feasible and can benefit any age group. The findings of this study have shown that Foundation Phase learners (i.e. grades 1-3) are capable of dialogical argumentation. That they can construct arguments through collaborative interaction, make claims and justify their answers through evidence and can even come up with a rebuttal by reflecting on their own ideas, and those of their peers and reach agreement.

The transcripts from the primary science lessons in this research indicate that relatively young children are capable of co-constructing arguments through verbal and non-verbal means and that they are able to use information to justify and support their claims.

5.9 Recommendations for further studies in the area

However the results of this study reveals that DAIM did not just enhance the learners' understanding of the NOS as well as SSI and IKS but also increased the awareness of the need to implement a Science-IKS curriculum in the classroom. This study has also revealed that grade three learners' could think and debate socio-scientific issues confidently once they have been trained to argue in a comprehensive manner. Although the results of the current study is encouraging, further research similar to (Keogh, Naylor and Browning, 2003) should place emphasis to fully understand the extent and robustness of young learners' science learning through dialogical argumentation and how this relates to their indigenous knowledge and cultural practice

More research (Sadler and Zeidler, 2005a) should also highlight the connection between science content knowledge and informal reasoning abilities. Different socio-scientific concerns will have different effects on learners' reasoning and it will also determine how the learner relates to the issue of the NOS. Zeidler et al (2002:362) notes that "Cultural influences are also suspected to be significant in the reasoning about these issues, and information in this area is vital to develop a curriculum and classroom environment that addresses controversial issues while respecting socio-cultural beliefs and traditions." Science classrooms can provide a platform where the probing of different views lead to a deeper consciousness about scientific processes

By engaging learners in reflective thinking on socio-scientific issues, teachers can challenge students' moral and ethical beliefs, next leading to explicit instruction in teaching many aspects of the NOS and indigenous knowledge and in what respects the two knowledge corpuses are compatible or otherwise.

But unless necessary opportunities for dialogues are created for learners to engage in these matters learners would continue to compartmentalize their knowledge. Sadler and Donnelly (2006) claim that to uphold scientific literacy where social scientific issues is vital, strategies for enhancing students' reasoning and argumentation skills in SSI in collaboration with IKS must be agreed upon.

The findings of the current study seem to indicate how the use of dialogical argumentation instruction could facilitate grade three learners' understanding of an environmental issue, namely water and water pollution, and how it impacts on their daily lives than would have otherwise been the case if they had been exposed only to the chalk-and-talk expository instruction which rely solely on standard text books. However further studies are warranted before any generalization can be made in this regard.

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Appendix 1

1: Water pollution questionnaire (WPQ)

Name: _____ Age: _____

Make a (✓) in the correct box.

Boy	<input type="checkbox"/>
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Girl	<input type="checkbox"/>
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Home Language:

Afrikaans	English	IsiXhosa	Zulu	Other
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Please complete the following questionnaire on water pollution.

All responses will remain anonymous and treated in confidence.

You may withdraw from the questionnaire at any time.

Answer all the questions in the questionnaire.

This is not a test

Question 1

The pollution of rivers and streams has become a serious problem around the world. Water pollution happens when people use the river to wash, as a toilet and a rubbish dump. Polluted water can look dirty, smell bad, make people sick and even kill humans, animals and plants. We need to look after the plants and grass on our river banks. Plants' roots stop soil from washing away. Some plants help to clean water and prevent flooding.

Question 1.1

Look closely at the pictures of the two rivers and tick off the differences you can see. Choose the correct answer.

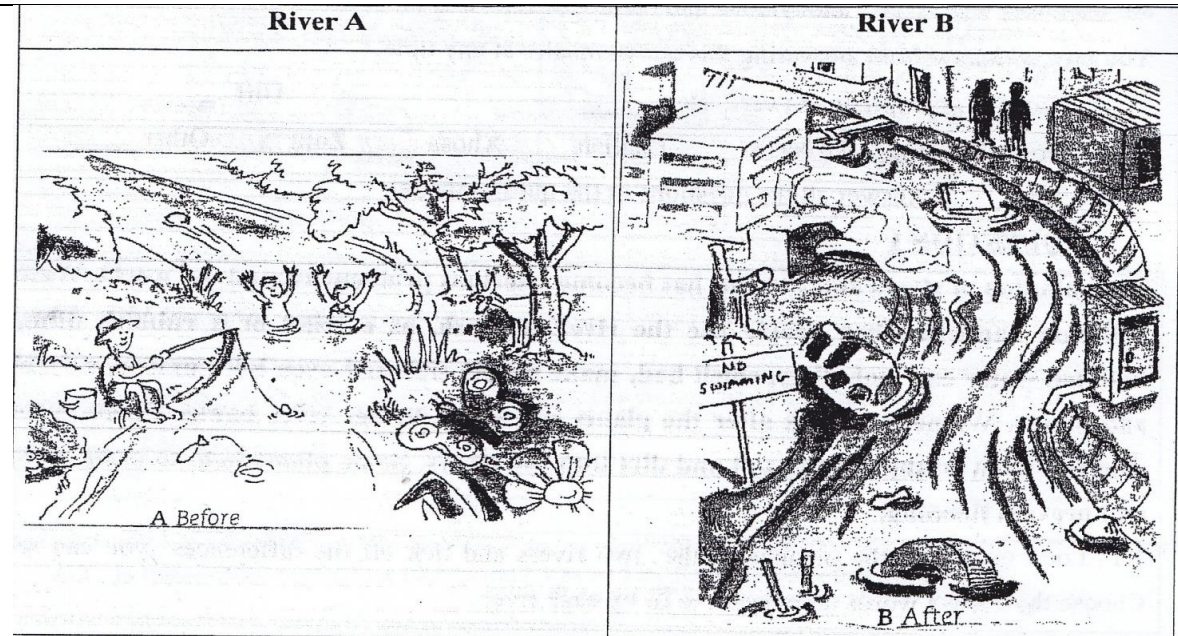


Illustration: New Africa books-Natural Sciences

	River A	River B	Reason
Clean river			
Swimming			
Dying trees			
Factory waste			
Growing trees			
Rubbish dump			
Polluted river			
No swimming			
Grass, flowers, butterfly			
Animals			
Houses			
Toilet near river			

(12)

1.2 How can a river or stream near you be saved from water pollution?(1)

1.3 Explain why river A will be less polluted than river B? (1)

1.4 If you live near river B, what changes will you make so that it can look like river A?(1)

1.5 What differences do you see between river A and river B? (1)

1.6 Which river do you like the most and why? (1)

1.7 Write 5 sentences on river A and river B and give it a title (name) (6)

River A

River B

1.8 Colour in both rivers. (1)

Total= (30)

Question 2

Choose the correct word or phrase from the list below and fill it in the open spaces.

(10)

smelly, polluted, murky, good, not smelly, at risk, not polluted, bad, not at risk

2.1 River A is _____, the water is probably _____.(2)

2.2 The quality of the water is _____ and the people using it are _____.(2)

2.3 River B is _____, the water is _____ and _____(3)

2.4 The quality of the water is _____ and the people using it are at risk.(1)

2.5 Why do you think river A is not polluted?(1)

2.6 Why do you think river B is polluted?(1)

QUESTION 3

Sipho's family lives close to a river and uses the water for drinking and other household purposes. Sometimes the water is very muddy and polluted.

Look closely at the picture and answer the questions that follow.

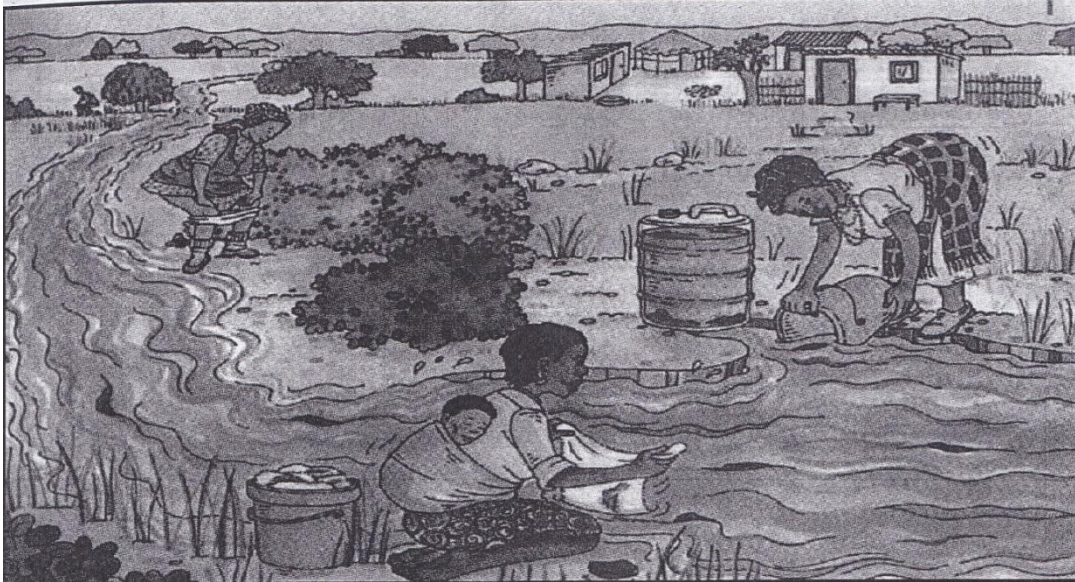


Illustration: Dept. of Water Affairs and Forestry. Republic of South Africa

Fill in the answers:

3.1 Where does Sipho's family get their water?
_____ (1)

3.2 Is this water clean or dirty? Give a reason for your answer.

3.3 Circle three things in the picture that makes this water unclean.(3)

3.4 What illnesses can Sipho's family get, if they drink the dirty water?
_____ (1)

3.5 Tick (✓) the correct answer (yes or no) and give a reason for your answer.

The water of this river can be used for :

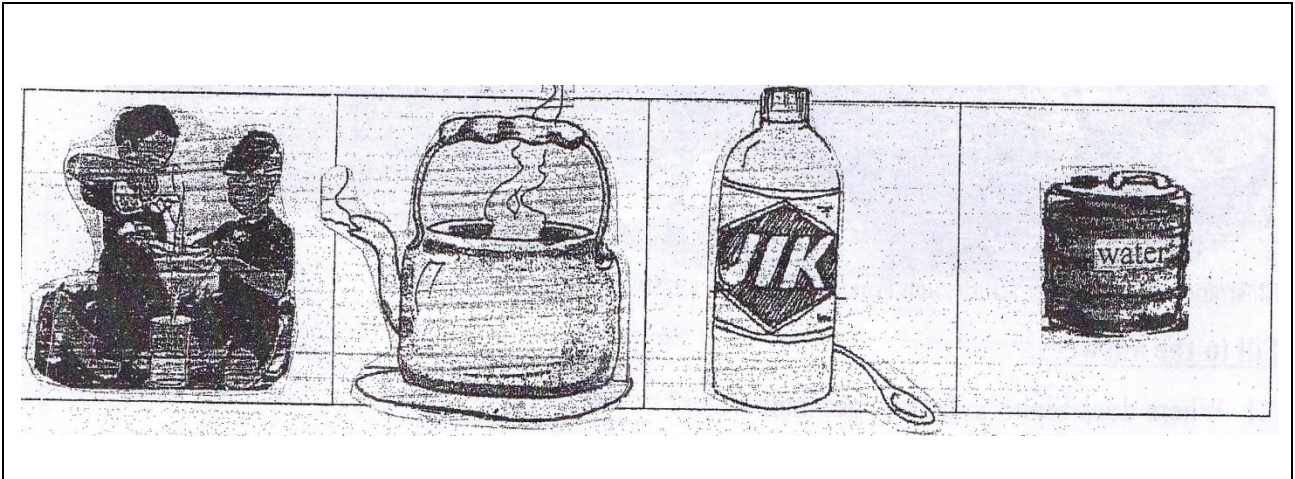
	Yes	No	Reason
Watering plants			
Prepare food			
Drinking			
Flush toilet			

(Total = 15)

Question4

Filtered water is not safe to drink. It has germs in that could make you sick. The germs is too small to get caught in the sand filter. You still need to kill the germs before the water is safe to drink.

How will you go about cleaning dirty water? Let the pictures guide you.



I will first _____.

Secondly I will _____

Then I will _____.

Finally I will _____.

I will first _____.

Secondly I will _____

Then I will _____.

Finally I will _____.

(4x1=4)

Question 5

Water from which source is safe to drink? Use a \checkmark to indicate your choice. Give reasons for your answers.

River water		
Bottled water we buy by a shop		
Borehole water		
Sea water		
Tap water		
Fresh rain water		

(3x2=6)

Question 6

Read the comic strip and answer the questions that follow:



Illustration: New Spectrum. A natural science course. Maskew Miller Longman.

6.1 Why does the mother, do not want the boy to play in the water?(1)

6.2 According to the boy, the water is clean. Do you agree or disagree with him? Give a reason for your answer. (2)

6.3 Is the mother really in a bad mood? Yes or No. Explain your answer.

(3x2=6)

6.4 Do you agree or disagree with the following:


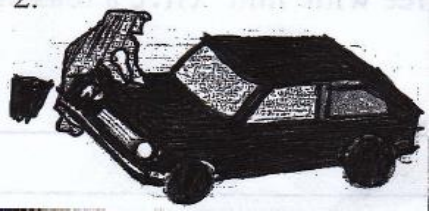


	Tick the correct answer	Agree	Disagree
6.4.1	Water pollution takes place when people dump waste in it.		
6.4.2	Filtered water is free of germs		
6.4.3	Polluted water is dirty, smell bad and contain germs that are harmful to people, water animals and plant life that can cause diseases.		
6.4.4	The environment can be destroyed by the pollution of rivers.		
6.4.5	Germs in water can be seen with the naked eye. Polluted water can be cleaned		
6.4.6	Polluted water can be cleaned for drinking.		

(6x1=6)

Question 7

Water is important to all living things: plants, animals and people. We can use and enjoy it without wasting it.

Indicate the water wasting actions with an X and the water saving actions with a √ in the space below, and describe briefly what the pictures show. Give a reason for your answer.

	X / √	Reason
<p>1.</p> 		
<p>2.</p> 		
<p>3.</p> 		
<p>4.</p> 		


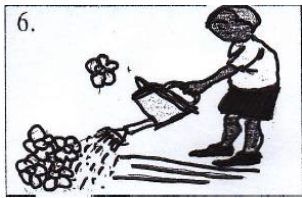

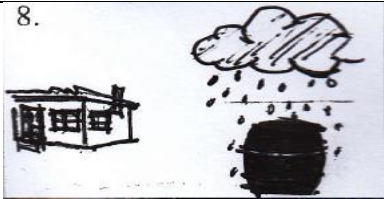
(Illustration: 2020 Vision for Water and Sanitation Education Programme –Dept. Water Affairs and Forestry. Republic of South Africa. Resource material).

4x1=4

Question 8

Water is important to all living things: plants, animals and people. We can use and enjoy it without wasting it.

Indicate the water wasting actions with an X and the water saving actions with a √ in the space below, and describe briefly what the pictures show. Give a reason for your answer.

	X / √	Reason
<p>5.</p> 		
<p>6.</p> 		
<p>7.</p> 		
<p>8.</p> 		

(Illustration: 2020 Vision for Water and Sanitation Education Programme – dept., Water Affairs and Forestry. Republic of South Africa. Resource material). 4x1=4

Appendix 2

Interview schedule

Focus group

- 1. What is your understanding of water pollution?**
- 2. What effect will polluted water have on people?**
- 3. How can polluted water be cleaned, to make it drinkable?**
- 4. Give several ways in which you can save water and not waste it at home and at school.**

Appendix 3

Responses of learners during various lessons

Phase 2

Example 1: Teacher makes a claim and poses a question thereafter.

Mary drinks water. Why is she drinking water?

L3: She is thirsty.

L5: She wants to take a tablet.

L2: She needs water to live or she will die.

L1: My sister is on a diet because she drinks a lot of water.

L4: If there is no water in the body then the organs will dry up. I m... mean dehydrate.

Teacher: This is excellent! Well done.

Example 2: Teacher makes a claim and poses a question thereafter .

Water is important? Why is water important?

L3: People need water to live.

L2: Plants need water to grow.

L4: Animals need water too.

L5: We need water for food.

L1: We need water to wash our bodies.

L2: Before a baby is born, he lives in water in the stomach. That is why my mother's great grandma says, water is so special because all people on earth live in water before they are born, and even if they are born they still need water to live. That is why water is so important.

L3: Babies don't live in the stomach. There is food in the stomach. My mum says that they live in a special bag near the stomach. I don't know what you call it know. I use to know it, because she told me.

Teacher: Can anyone help L3?

L5: They call it a "baar". Teacher: You are nearly right but that is an Afrikaans word. Let's first look the word baar up in the dictionary, but we first need to go to the Afrikaans side.

L1: I found the word baar, but there are many words with baar.

L3: I know the word. It is a uterus. That is what my mother said. L4: U can also call it a womb. It is also written in the dictionary.

Teacher: *Fantastic! Now let's first go and look the word uterus up to get the meaning, and then the word womb. Can L1 read the meaning to us.*

Teacher: That's wonderful! (She furthermore asked numerous questions to find out if they agree or disagree with each other's claims).

Teacher: (Ask question to L1) Do you think L3 is right with regard to what she said? That people need water to live.

L3: Yes, she is right, but I don't think that the baby live in normal tap water.

Teacher: (Brings in vocabulary agree and disagree) So do you agree or disagree with L3?

L3: Yes, I agree. Teacher: Well done! Can you give me a reason for agreeing with L3.

L3: I agree because th..they can die. I also saw a picture of an unborn baby in the uterus. So I also agree with Teacher: Excellent!

Learners gave several reasons and were now eager to engage in the discussion. The teacher now introduces the learners to the new vocabulary namely, claim, reason and grounds. She emphasizes that the sentences, "She is thirsty" and "Water is important" is a called a claim. She goes further by saying that a claim is a fact, something that is true or said to be true. The teacher also mentions that to make your claim true you have to provide reasons, or we can say grounds. The learners now look these new words up in their dictionaries and read the meaning of it. These new words are now written in the big class dictionary as well as in their own dictionaries.

More meaning is now put to these claims. A table is drawn on a big piece of paper by the teacher. In the first two columns she writes claim and reason/grounds and poses a question to the learners.

Teacher: What was the first claim that I made? L3 answers: *She is thirsty.*

Teacher: Well done my girl. Now I want you to come and write it in the claim column.

Teacher: (repeats the question again) Why is she drinking water? The learners name all the reasons as mentioned earlier.

Five learners are chosen each to write one of the reasons in the reason/grounds column. The same process is precisely followed with: Water is important. The teacher now chooses one word from a group's mind map. She then ask the learners to build a sentence /make a claim with the specific word. They must also provide a reason / grounds for it.

The claim is then written in the correct column on a page. Learners' give reasons/grounds for their claim which is also now written in the correct column. For example: Table 3.2 depicts an example of 1 learners' comments in a discussion on how they chose their word.

Table 3.2. A written example of group learners' claims backed up with valid grounds.

Group	Word	Claim	Reason/Grounds
1	Dirty	The water is dirty.	L2: There is dirt in it. L4: I see papers in it. L1: There is leaves, tins and sticks in it.

This example done with the whole class, gave learners clarity on how to do the task when required from them. At the beginning it is best not to bring in too much information, because it can confuse the learner. As the lessons unfold through questioning, group members come up with different claims. The word counterclaim can then be introduced to the learners and added to the table. After the given example the learners are now required to do it in their group.

The group however had to discuss and chose a word from their own mind map drawn up previously in lesson 1, activity 1 and formulate a claim which they then have to complete on a page which had to include reason/grounds by writing it in the correct column as in the example. The except below is representative of the learners' discussion.

Transcript: Group 1

L1: What word can we choose? L3: Take a easy one where we don't have to think long.

L5: Let's choose flow. L2: What can we write about flow. L5: We can write water can flow.

L2: Now what is the reason? L5: Uh...uh.. that it can...L2: That it can what? L5: I don't know. L4: We need to choose another word and we must hurry up. L4: I know what to write. The water is dirty. L3: And what is the reason? L4: There is dirt in like papers, tins..

L2: Yes, that's correct. I like that one. Are we all going to take L4's sentence? L3: It's not a sentence but a claim. L2: I know but it's also a sentence. We must get done now. Put up your hand if you like the sentence. L1: All the hands are up s..so we take the sentence. Hurry and write it on the page. L5: Don't' rush me, I don't like it.

After completion, the groups had to present their ideas to the class which was followed by a questioning session. Other groups also had the opportunity where they could add further ideas. Five to ten minutes were allowed for each presentation. Due to space limitation I will not be allowed to include all the groups discussion and presentation here therefore only two groups have been chosen. After the presentation, each group member had to complete their claim and reason or grounds on one big page which was then put up on the classrooms walls. This also gave learner's the chance to look at in on a daily basis. It was evident, how they would read it aloud to each other and informally give other reasons or grounds which were not on the page. After observing this, I suggested to them, that if they come up with other reasons or grounds they are free to fill it in, in the extra column with another colour crayon. This kept them involved all the time and not just during the lessons. See the under mentioned transcript of all the groups.

Table 3.3. Claims and counterclaim made with valid grounds by different groups.

Group	Word	Claim	Reason/Grounds	Counterclaim	Reason/Grounds
1	Flow	Water can flow.	L2: It moves. L4: It don't stand still. L1: I have seen it moving.	None	None
2	Salty	Sea water is salty.	Tasted it.		
3	Water	Water is life.	People, animals and plants need water to live. If there's no water then we all die.		
4	Clean	The river is clean.	No dirt in it.	The river is not clean.	Tiny pieces of dirt can still be in the river

At this stage many of the groups were able to make a simple claim of some type and provide evidence to justify it. This led to further dialogical interaction where they questioned each other's claims, evidence or add to their current ideas. In my opinion, an argumentation activity will not be guided with a set of answers that were usually the order of the day. It will probably adjust during such a session, as learners supply grounds to justify their claims.

3.11.3 Lesson 3: Activity 3

In their groups they also had to discuss and think of ways how people cared for water in the past and compare it with how people looked after water today if there were any ideas coming up in the group. Each group had the opportunity to present their presentation. Due to space limitation I will only be able to illustrate group 2 and group 4's presentation.

Group 2's presentation

Presenter(L1): *Our group chose the word salty. Everyone liked it except L2. She wanted the word white but she and the rest of the group could not think of a reason. L3: or grounds you must say. L1: I mean grounds. Then we all took L4's word salty and he made the sentence. Our sentence oh..I mean claim is: Sea water is salty. The reason is that you taste it when we swim, because the water goes in your mouth.*

The rest of the class now pose questions (Q) to the presenter (L1) as well as to the rest of group two. The presenter is allowed to discuss a question with his group if he does not know the answer.

Q: Why did you choose the word salty: L1: *We chose salty because we had a reason for it.*

Q: Where did you taste the salt water L1: *At the beach.*

Q:How does salt water taste? L1: *It taste salty and it's not nice.*

Teacher ask questions to presenter and his group:

Q: Where can you also get salt water?

L1: *I don't know. Can I ask my group?.....*Teacher: Off course!

(L1) *I can make salt water at home.* Teacher: *You are absolutely correct.*

Q: Does salt water from the sea and salt water at the house taste the same? You can talk to your group if you need help.

(L1)Salt water at home taste the same as salt water from the sea. On what grounds do you say that? I tasted salt water before. *Teacher: I agree with you. Well done.*

Group 4's presentation

Presenter: L5: *Our group chose the word clean. L3 chose the word and everyone agreed that we must take the word clean. Then I made a sentence with the word. The sentence is written on the paper. Our claim is: The river is clean and the reason is that there is no dirt in the river.*

L4 also mentioned that in Ghana where she comes from, people use to respect rivers. She told us a short story which she will share with you.

Teacher: That's wonderful, and we are all curious to hear what she has to say.

L4: In Ghana old mama use to tell my dad and his brothers water stories. Old mama said that water is important and that rivers were never dirty when she was a child.

People did not mess in it, or threw dirt in it. If people waste water, or treat it like nothing, then the gods punish the people that do it. The gods want people to look after water so that there can be enough water for all people. The people were scared of the gods, that is why they looked after the river. I see many dirty rivers in South Africa.

Teacher: That's wonderful. Do you have any questions to ask L4?

L5: Who is old mama? L4: It is my dad's great grandmother.

L1: What god are you talking about? Is it God that's in heaven?

L4: No. I think it is a special god that looks after water.

L2: U mean a fake god. Did the people really listen to the fake god? What is the evidence?

L4: Yes, they listened because they did not dirty the rivers. I also see clean rivers of the past on the television.

L2: You said that it is not a God that lives in heaven. S..s I think they just want to scare the people to look after the water.

L1: Is it like a oupa Dulie, that scare children to eat their food?

L5: Yes. I think so and agree with what L4 said. When I was young, I did not like eating veggies. Sometimes my parents would also scare me in eating my veggies or else oupa Dulie will do something to me. Scared of oupa Dulie, then I would eat my food. I think we must not ask L4 so much questions, because she told us what her dad told her. At least the people looked after the water even if it was a fake god. Oupa Dulie was fake and I also ate my food.

Teacher: What an interesting conversation. Can we continue now with other questions.

Q: Why do you say the river is clean? L5: There is no dirt in it.

Q: How does a clean river look? L5: It look pretty.

Q:What can you get in a clean river L5: *There's animals like tadpoles and fish in.*

Q (L3) *I disagree with L5 because the river can still be dirty, even if you take out the dirt.*

(L2) *L3 is right. I agree with him. Tiny dirt can go to the bottom of the river and you can't see it.*

Teacher: *L3, you and L2, disagree with L5: Why do you disagree?*

L3: I disagree with L5 because the river is still dirty. Teacher: (smiling) Yes, you are right. So that means you did not make a claim, but a counterclaim. The teacher explains the following to the learners: A counterclaim is when you think differently and disagree with another person's claim, but you must give a reason, or grounds to make your counterclaim true. That means we must write in the other two open columns, but before I do that, can you repeat your counterclaim?

L3: The river is not clean.

Teacher: And your grounds are?

L3: Tiny pieces of dirt go down to the bottom of the river and we cannot see it.

Teacher: You are absolutely correct. Germs cannot be seen with the naked eye. Brilliant! We now have four claims with evidence and one counterclaim with evidence. This is amazing. and interesting. Can you give me another word for reason ?

L3; It is gr... grounds.

Teacher: Now let's fill in the counterclaim and grounds in the table.

Hall and Sampson (2009:16) points out that "In order to engage students in scientific argumentation as part of the teaching and learning of science, the nature of the typical classroom activity and discourse patterns need to change". Teachers must give students the chance to discuss and assess critically the reasons offered in support of any thoughts. They further suggests that faulty claims should not be corrected by teachers while students are busy working. She must rather allow other groups of students to argue with and give evidence to support more scientific valid claims. If students are comfortable with the nature of scientific inquiry and argumentation a teacher must withdraw her support from the students. The researcher now start interacting with the learners through various questions.

After learners saw the information on the table it seemed that they were now more motivated to go on arguing. The researcher used various examples to ensure that the learners understood the difference between a claim and evidence or grounds and also use the words like agree and disagree in their vocabulary.

Duschl & Osborne (2002) states that it is very demanding to construct ample explanations based on evidence and that suitable reasoning is fundamental, but a particular complicated element of the process of scientific inquiry. Focusing on too many facets in one lesson will cause them to lose interest. I agree with Hall & Sampson (2009) that students need to focus each day on one specific aspect of an explanation by giving daily hints to them what to look out for. Giving continuous support to learners during the lessons are essential if you want them to develop. In my view it is to the advantage of the learners if scientific enquiry not be rushed with the learners but gradually done with them. As the lessons unfold a vocabulary list is drawn up. The teacher then urge learners to regular use these words during their discussions.

Group 1 now gets the opportunity to question group 3 on their mind map:

L3: *Why did you write good or bad on the mind map and what does it mean?*

L2: *We wrote it because water can be good. Water is good because all people, animals and plants need water to live. If there is no water then everything will die and that's why we also said that water is life.*

L1 (group 3) *Can I answer the bad part of water:*

Teacher: surely!

L1: (group 3) *When water is bad, then it can damage places and houses if there is a big storm. Our geyser broke in the night. and when we woke up the whole house was full of water and it destroyed the mat and the furniture.* Teacher: That's terrible!

Questions from group 2:

L3: Where do you get fresh water and salt water?

L 4 You get fresh water in rivers and streams. Salt water is in the sea.

L1: Can you drink salt water?

L 2: No, because it can make you sick.

Questions from group 4

L2: What is clean water and what is polluted water?

L3: Clean water is not filled with dirt and polluted water has dirt in.

L3: Why is water a liquid? L4: It can flow. It don't stand still.

Questions from group 5

L1: Why is water important?

L 5 Plants need water to grow. People and animals need water to survive.

L3 What is water used for ?

L5: Water is used for drinking, washing, and to cook food.

After the questioning session the teacher asked each group to formulate a claim based on their question and also provide the grounds for it. Thereafter they had to come and share it with the class. There was however no counterclaims. See the under mentioned transcript of all the groups claims and grounds.

Table 3.4 Claims backed up with valid grounds by different learners in each group.

Group	Learner	Claim	Evidence
1.	L3 L2	1. Water is good. 2. Water is bad.	People, animals and plants need it to live. It can destroy houses, places in a storm. and furniture.
2.	L4 L1	1. Sea water is salty. 2. Water is fresh.	I tasted it while I was swimming. When it is crystal clear.
3.	L3 L5	1. Water can be dirty. 2. Water can be clean.	There is dirt in. If there is no dirt in.
4.	L1 L2	1. Water is important. 2. We use water to wash.	It let plants grow. It removes the dirt.

The researcher now start interacting with the learners through various questions. The more questions are asked, the more learners are getting involved. After learners saw the information on the table it seemed that they were now more motivated to go on arguing. I used various examples to ensure that the learners understood the difference between a claim, and evidence or grounds and also use the words like agree and disagree in their vocabulary.

The more learners are exposed to scientific enquiry and dialogical argumentation they will feel more comfortable. This is now an appropriate time for the teacher to withdraw her support. If learners are caught up with an activity, it is best to pose questions to the whole class to see if other learners can assist and come up with a solution.

One will be surprised how learners can support each other. It is of utmost importance that when help is needed, that the correct answers must not just be given, but questions rather asked as to guide learners through the process. This will stimulate them to think further and result in them solving their own problems.

The under mentioned activities were part of the post-test of learners discussions and of co-constructing arguments which resulted in claims counterclaims, grounds and rebuttals. These were further discussed and analyzed in chapter four where the argumentation level of individual learners were indicated as well on the under mentioned activities namely:

- Comparing, discussing and co-constructing arguments of the substance that is in container A and B.
- Discussing and co-constructing arguments on a picture of a clean and polluted river.
- Doing an experiment on how to clean polluted water for drinking.
- Indicating water wasting and water saving measures.
- Co-constructing arguments during a post-interview.

Lesson 4: Activity 4(a)

This phase will consist of numerous lessons so as to develop learners nature of scientific inquiry and dialogical argumentation. As the lessons unfold a vocabulary list is drawn up. The teacher then urge learners to regular use these words during their discussions.

Activity 4(b):Continuing of mind map

The rest of the class were now given the chance to pose questions to the whole of group 3 regarding their mind map. Each learner gets the opportunity to answer a question. This was quite interesting. As far as possible the teacher did not intervene with the groups or try to lead the learners to the correct answer. Each group had to write down their questions which they will use at a later stage.

Thereafter the teacher will correct the learners misconception with regard to the following: (1) that water is see through instead of transparent, (2) that it is crystal clear and not white. (3) that rivers are clean if you take out the dirt (4) polluted water looks black / brown.

Group 1 now gets the opportunity to question group 3 on their mind map:

L3: *Why did you write good or bad on the mind map and what does it mean?*

L2: *We wrote it because water can be good. Water is good because all people, animals and plants need water to live. If there is no water then everything will die and that's why we also said that water is life.*

L1 (group 3) *Can I answer the bad part of water:* Teacher: *surely!*

L1: (group 3) *When water is bad, then it can damage places and houses if there is a big storm. Our geyser broke in the night. and when we woke up the whole house was full of water and it destroyed the mat and the furniture*

Teacher: *That's terrible!*

Questions from group 2:

L3: *Where do you get fresh water and salt water?*

L 4 *You get fresh water in rivers and streams. Salt water is in the sea.*

L1: *Can you drink salt water?*

L 2: *No, because it can make you sick.*

Questions from group 4

L2: *What is clean water and what is polluted water?*

L3: *Clean water is not filled with dirt and polluted water has dirt in.*

L3: *Why is water a liquid?*

L4: *It can flow. It don't stand still.*

Questions from group 5

L1: Why is water important?

L 5 Plants need water to grow. People and animals need water to survive.

L3 What is water used for ?

L5: Water is used for drinking, washing, and to cook food.

After the questioning session the teacher asked each group to formulate a claim based on their questions and also provide valid grounds for it. Thereafter they had to come and share it with the class. There was however no counterclaims.

See the under mentioned transcript of all the groups claims and grounds.

Table 3.5 Claims backed up with valid grounds by different learners in each group

Group	Learner	Claim	Evidence
1.	L3	1. Water is good.	People, animals and plants need it to live.
	L2	2. Water is bad.	It can destroy houses, places in a storm. and furniture.
2.	L4	1. Sea water is salty.	I tasted it while I was swimming.
	L1	2. Water is fresh.	When it is crystal clear.
3.	L3	1. Water can be dirty.	There is dirt in.
	L5	2. Water can be clean.	If there is no dirt in.
4.	L1	1. Water is important.	It let plants grow.
	L2	2. We use water to wash.	It removes the dirt.

The researcher now start interacting with the learners through various questions. The more questions are asked, the more learners are getting involved. After learners saw the information on the table it seemed that they were now more motivated to go on arguing. I used various examples to ensure that the learners understood the difference between a claim, and evidence or grounds and also use the words like agree and disagree in their vocabulary.

Lesson 5:Activity 5(a)

In this activity the teacher now demonstrates to the learners that water takes the shape of the container by doing the following. She puts five different shaped containers (round, rectangular, square, oval and cone) on a table. One learner from each group now has to pour some water in a container. Each learner had to explain what he sees in the container after throwing the water in it.

L1: *The water is shaped like my container..* L2: *The water looks like a circle.* L3; *It looks like a square.* L4: *It is round.* L5: *The water looks like a rectangle.*

Teacher: *You each looked at your container and told me that the water in your container has a different shape. What does it tell you?*

L1: *If you throw water in a container, it takes that shape.*

Teacher: *Excellent! You are right. Water takes the shape of the container.*

Lesson 5 Activity (5(b))

This activity was hands on. The resources were a small model of a river and a farm with little plants in the soil, tin insect repellent (doom, target, ...) and a sandwich. Learners had to predict what would happen if doom were to be sprayed on the sandwich.

L3: *It will be poisonous.* L4: *It will smell bad.* L2: *We can't eat it.* L1: *It will become rotten.*

Doom is now sprayed on a sandwich and offered to the learners. In their groups they must first have an intra-dialogue with themselves and then afterwards an ultra dialogue with their group. They then had to make a claim and provide grounds for it.

Transcript of group 5's discussion:

L3: What can we write as our claim. L1: Let's write: The bread is poisonous. L2: Yes, but what is our evidence? L4: It has been sprayed with doom and it has a strong smell. L2: Can we give more reasons. L3: Doom cannot be used on food because it is suppose to kill insects like ants and flies and not people. L1: I think L3 is right because if the insects die, then it can make people sick.

L3: Doom has chemicals in it.

L4: So people can die of the chemicals in the doom and it is also dangerous. L2: All chemicals can hurt people. L1: A person get different chemicals, like domestos to wash the floor, or clean the toilet. L5: Chemicals have a strong smell.

Teacher: Well done! What I have heard from the discussion is clearly that chemicals is harmful. Now let's formulate or make a claim. By questioning the learners it will guide them in formulating or making their claim.

Teacher: What is harmful?

L3: Chemicals are dangerous. Teacher: What is the reason for saying that or what is your grounds? Can someone else answer now?

L2: It can make you sick or it can kill you. Teacher: Excellent.

Teacher: Now imagine if chemicals or pesticides are being sprayed on the crops on a farm that is near a river. Insect repellent are now being sprayed on the "crop" which also result in the mixing of soil and pesticides. Thereafter water is being sprayed on the "crop" representing the rain. Learners now had to predict individually what is going to happen after observing it by writing it down. Then it is discussed within their groups and presented to the class.

Group 3's discussion:

L2: I think the pesticides will only stay on the crop. L4: I disagree, because it can also go in the sand. L1: I also agree with L4 because it can drip down to the soil, I mean sand. L3: When my mom sprays air freshener in the house it don't just stay in the air, it comes down because I can feel my hair getting wet.

Then water was sprayed over the so called crops which resulted in the mixing of soil and pesticides runoff that went into the river polluting it. They then had to answer the following questions based on their observations. Learners now had to write down their observations.. Thereafter they had to discuss it in their group by completing a flow diagram. They had to choose flashcards and put it in the correct order, demonstrating how rivers are polluted through pesticides run off. In their group they also had to discuss and build arguments around the dangers of pesticides. They had to draw up a table to illustrate the claims , evidence, counterclaims and even rebuttals if there were any.

Lesson 6 Activity 6

This activity was hands on. Learners had to predict and then write down their observations individually, and thereafter discuss it within their groups making claims, counterclaims and justify it with grounds. The activity is as follows: A clean white sock was put over the exhaust pipe of a car. The car was switched on for a short while and then switched off again. After some time the sock was removed and shown to the learners.

Transcript of group 5's discussion :

L2: The smell is terrible. L4: It is the smoke that comes out of the exhaust pipe. L3: It is like a gas. L5: No, it smells like petrol. L2: It also smell like a chemical. L1: I feel like vomiting. L3: It's polluting the sky. L1: So the smoke that comes out of factories is not good for us. It pollutes the sky. L2: You're right.

L5: The smell is very strong. L4: Look!, the white sock is getting black. L2: It is the smoke that made the sock black. L4: S..so the smoke of factories that pollutes the sky is full of chemicals, just like the tin of doom. L3: It can make us sick. L2: We can also die. L4: Can the sock get clean again? L2: I think so, but I'm not sure.

Teacher: I've listened to all your interesting discussions. L2 of group 5 said that the smoke smelled like aWho can assist me?

L2: I said it smelled like chemicals. You are correct.

Teacher: L4 also mentioned something about factories. Can anyone remember what she said?

L3: She said that smoke that pollutes the sky is full of chemicals.

Teacher: Excellent! So when it rains,.. while the sky is polluted with smoke, what do you think happens? Each person must give their own idea and then discuss it within their group.

Transcript of group 2's discussion on the above

L3: The smoke and rain come together. L4: What do you mean? L2: I think he mean the smoke and rain mix together. L4: I agree with you because the smoke is already in the sky and when it rains, the smoke touch the rain. L5: You can't say the rain touch the smoke. The rain mixes with the smoke.

Class discussion

Teacher: I think I agree with what you said. When it rains, the rain mixes with the smoke that pollutes the sky and we call it acid rain. What causes the acid rain?

L3: Rain is clean, so I think it is the chemicals in the smoke.

Teacher: Well done! So what effect will acid rain have on planet earth?

L5: Real acid is dangerous. It can burn you. I read in a magazine how someone threw acid on a lady's face and her face look horrible. She is now blind and must stay in hospital.

Teacher: Is the acid that burnt the lady the same as acid rain?

L4: No. because the acid that burnt the lady was bought at the shop, and acid rain was not bought at the shop. You buy acid in a bottle.

L2: I agree with L4, you get acid rain when rain mix with smoke that pollutes the sky.

Teacher : How dangerous is acid rain then?

L5: It is dangerous because you get chemicals in the smoke.

L3: I think it can make people sick.

Teacher: Excellent. You gave very good ideas. Yes, acid rain is very dangerous. It can destroy the environment. Acid rain lowers the oxygen level in the water and fishes and plants living in water can die. Learners now had to draw up their own claims and grounds with regard to the acid rain activity. Thereafter a video was shown to the learners on how air pollution takes place.

Lesson 7: Activity 7

A variety of household chemicals have been put on display namely: dishwasher, shampoo, washing powder, domestos, medicine, cups, doll, cloth, socks, hand towel, containers, water. Learners need to choose an instruction out of an envelope and follow it up. The instructions were as follows: (1) The doll's hair is dirty; (2) Clean the sink; (3) Juice fell on the floor and it is sticky, (4) Throw away the medicine. Each group must gather their own items from the display to do the activity and then select a member out of their group to do the activity. Individual learners must first predict, observe and write down their observations.

Thereafter they engage dialogically in their group and need to come up with claims, evidence, counterclaims.etc..The aim of this activity is to make learners aware that household chemicals, as well as medicine pollutes water if it goes down the drain.

Teacher: Now just as household chemicals pollute our water, factories also pollute our rivers by letting factory waste into our rivers. Factory waste also have chemicals in and it is not good for our rivers.

Lesson 8: Activity 8 (a)

A short video was shown to the learners on how urban people got their water and how rural people got their water in the past and they then had to compare it with how people get their water at present. They first had to do the task individually and then engage in their groups to reach an agreement. Thereafter they then had to draw up a list of the things they found interesting.

The following transcript is based on the discussion of lesson 8. (Group 1)

Urban people getting water in the past

L3: Where is the girl going with the bucket?

L4: I think she is going to get some water.

L2: So that means, they don't have a tap in their house. L1: Why don't they have a tap in their house?

L3: Perhaps they don't have money to put in a tap

L1: Yoh! They walk very far just to get one bucket of water.

L3: I wonder how long the bucket of water will last?

L1: It will not last long.

L4: Will the water be enough to wash, cook food, and drink it.

L2: I think so.

L1: Why is the mother scolding her?

L4: Didn't you see, as she was coming home with the bucket of water some water spilled.

L3: But that is nothing. I spill water at home and my mother are not angry with me.

L4: It is something, because I think water may not be wasted.

L4: They close the bucket. L5: So that dirt can't go in the water.

After agreeing on the claim the group members had to draw up a table indicating the claim they agreed on. They however came up with various grounds to justify their claim. There were no counterclaims.

Table 3.6 Learners' claims provided with valid grounds after watching a video on rural people fetching water.

Claim	Grounds	Counterclaim	Grounds
<i>The girl is going to fetch water at the tap.</i>	<i>L1: There is no more water at home.</i>	<i>None</i>	<i>None</i>
	<i>L2: The mum want to cook food.</i>		
	<i>L3: They need water to wash.</i>		
	<i>L4: They want to drink it.</i>		
	<i>L5: They want to make tea.</i>		

The following transcript is based on the discussion of lesson 8 of group 2:

People getting water in rural areas.

L2: The woman is on her way to the river.

L1: I think she is going to fetch water.

L4: I disagree with you. She is not going to fetch water because she has no bucket in her hand.

L3: You don't just need a bucket to put water in it. You can put water in anything that will keep it. There is a pot on her head.

L2: The pot on her head is different from the pots that I know.

L4: You can call it a jug or a water jug.

L1: It looks so quiet by the river. L3: Look how green is the grass and the trees.

L4: There's no people near the river.

L1: The woman takes a small.... I've notice that she carefully puts the water jug in the river to fill it up.

After agreeing on the claim the group members had to draw up a table indicating the claim they agreed on. They however came up with various grounds to justify their claim. There were no counterclaims

Table 3.7 Group 2 Learners' claim provided with valid grounds after watching a video on rural people fetching water.

Claim	Grounds	Counterclaim	Grounds
<i>The woman is going to the river to fetch water.</i>	<i>L1: They used up all the water.</i>	<i>None</i>	<i>None</i>
	<i>L2: They don't have a tap to get water.</i>		
	<i>L3: They need water to wash.</i>		
	<i>L4: They want to drink it.</i>		
	<i>L5: Water is important because people and plants need it. If there's no water then we can all die.</i>		

Lesson 8 Activity 8(b)

In this activity the learners had to look at the two rivers in the video namely: A river in the past and compare it to a river of the present as in the video. They had to make claims and give grounds. Below is a transcript of two groups comparing past and current rivers.

Table 3.8. Group 1 learners' claims made with grounds after comparing past and present rivers in the video.

Past rivers	Current rivers
1. Rivers were clean.	1. Rivers are polluted.
2. No houses near the river.	2. People live near rivers.
3. No papers or dirt near the river.	3. The river is full of dirt.
4. Trees and plants next to river is green.	4. No trees and plants.
5. Animals near river.	5. No animals by the river.

Table 3.9 Group 2 learners' claims with grounds comparing past and present rivers in the video.

Past rivers	Current rivers
Water is clear.	Water is brown.
Houses far from the river.	Houses near river. River are filled with dirt.
Plants next to river.	No plants growing near river.
No toilets near the river	River is used as a toilet.
They look after the river.	The people don't care about rivers. They wash clothes in the river.

Learners now had to formulate a claim, and provide grounds after comparing the two rivers and put it in table form.

Table 3.10 Group 3 learners’ argument about whether or not the river is clean

Claim	Grounds	Counterclaim	Grounds
<i>The river is clean.</i>	<i>L1: There is no papers in it.</i>	<i>None</i>	<i>None</i>
	<i>L2: No houses near the river.</i>		
	<i>L3: No papers or dirt near the river.</i>		
	<i>L4: A lot of trees and plants.</i>		
	<i>L5: Animals near river.</i>		

In Table 3.10 above, group 3 learners appeared to make only a claim but provided several grounds to justify it. No counterclaims were made.

Lesson 9: Activity 9

Four different topics related to all the above activities were now thrown in a hat. One member of each group had to draw a topic out of the hat which they then first had to complete individually and then discuss it within the group. Learners were now inspired to engage actively through discussion by not repeating another person’s claim, but to rather add to it. It’s a ground rule that learners need to put their claims and evidence in full sentences.

Transcript 1

Group 's discussion on: water

L3: Water is important. People need water to live.

L2: I agree with you. Water is life. Without water we can't live.

L1: You are right. If there's no water on earth then the people will die.

L4: An ..and plants and animals need water to live or they will die too.

L1 I agree with L4. It's not just people and plants that needs water, everything on earth needs water, like insects, birds, or..or the earth will be destroyed.

L4 :I agree with L1 b.. because If there's no water, then plants can't grow.

L3: That m.. means we need water to live. So water is life

L1: I agree with you. That's right.

L3:Water is life, but it can also destroy things.

L2: I disagree with L3. How can water destroy things if it is suppose to be life.

L3:Water destroyed the earth in the bible b..because people sinned and Noah lived in the ark with his family.

L2: Oh, now I see. S..so I think you are right and I agree with u. Water is life, but it can also destroy things when it rains without stopping or when there's a storm.

L1: Water can be clean when there's no dirt in.

L2. Water is polluted when there is dirt in.

L5: I agree with L1 and L2 but I also want to say that a person can't drink salt water.You can get sick.

Group 2's discussion on: Uses of water

L4: We use water to wash clothes to remove the dirt.

L3: We need water to make food.

L2: I don't think water is needed to make food.

L3: What! It is needed.

L2: My mother has a special lid she puts on the pot when she makes food. She don,t throw water in the pot. She says there is water in the vegetables and in the meat if she rinses it.

L2: My mother puts the stove on low and then the steam make water. When you throw water in the pot, it is not used correctly.

L3: Not all people have the pots your mother got. s..s then we must throw water in our pots to cook food.

L1: I know u get these pots, but how can you get steam in the pot if your mother did not throw in water.

L4: If you eat a tomatoe there is water in, Also in a carrot and a potatoe. Animals need water and people too.

L3: If there's no water we all will be dead.

L1: Plants also need water to grow and insects.

L3: People swim in water. L1: Animals live in water . L4: Water is important L2: We cannot go without water.

Group 3's discussion on : Water pollution

L4: When people throw papers in the water they pollute it.

L2: It is not just papers that can pollute water, any dirt can pollute water.

L3: Sticks, leaves, and stones can pollute water and we cannot go without water.

L2: Yes, water let us live on earth.

L1: Water can be dirty and we may not drink it. You can get sick.

L3: Yes, dirty water can make you sick, but if u take the dirt out then it is clean.

L2: I disagree with u. If the dirt is out, there is still germs in that you can't see.

L4: I agree with L2 and it there is also other things that pollute water like pesticides.

L3: Things like acid rain and...a..

L1: Dishwasher, shampoo and medicine also pollutes water.

L2: Water is also polluted when you use it as a toilet.

L3: Factory waste also pollute water.

L4: You can get sick if you drink polluted water and even die.

Group 4: Saving water

L2: If we waste water, there will not be enough water for people on earth.

L1: My dad wet the garden in the night to save water.

L4 U must drink out of a cup and not waste water. L2: We must not waste water because then there will not be enough clean water for people on earth. L4 People need water or else they will die. L1: You save water by fixing a tap that drips. L1: Water can be saved by collecting the rain in a drum. L3: U can save water by taking a shower or by collecting rain.

The lessons ended off through the following:

Group 1: Role play where “a mum took her sick baby to the clinic after she made a bottle of milk with water she got from the river” It is also emphasized in the play how to make a solution to stop the baby’s diarrhea.

Group 2: Poster display on stopping water pollution.

Group 3: Writing their own short poems or rhymes on stopping water pollution.

Group 4: Rap song on water pollution.

The whole class listened to the song: “Don’t kill the world” and then sang along. They afterwards filled in the missing words in the song. At this stage it was now evident to see how the learners language improved tremendously through argumentation. They gained confidence and were not scared to make mistakes of any kind. They also accepted the fact if other learners disagreed with them and did not see it as a personal attack.