CONCEPTIONS OF CONSERVATION OF ENERGY AMONG GRADE SEVEN LEARNERS IN TWO CAPE TOWN SCHOOLS

A Full Thesis Submitted in Fulfilment of the Requirement for the Degree:

Masters in Science Education

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DECLARATION

I declare that this thesis, **"Conceptions of Conservation of Energy among Grade Seven Learners' in Two Cape Town Schools"** is my work; that it has not been submitted before for any examinations or degree purposes, in any other university, and that all sources I have used or quoted have been indicated and acknowledged by complete references.

Nwakaego Esther Malin Okoroh

Signed:

Date: December 2020.

ACKNOWLEDGEMENT

First and foremost, I thank God Almighty for the grace He has granted upon me through this great journey and for giving me the knowledge and good health throughout the study period.

My deepest gratitude goes to my supervisor Prof. M.B. Ogunniyi for his untiring effort, patience, assistance and guidance throughout this study and the knowledge he has impacted on me. I reckon him as my divine helper and a good father. I thank him for allowing God to use him to fulfil part of His plans for my life. The words of my mouth cannot thank him enough, may the God Almighty bless him abundantly beyond measure, in Jesus Name, Amen.

To Dr. Paul Iwuanyanwu, I greatly acknowledge his general support, advice, motivation and the trust he demonstrated especially at the difficult phase of this research work. I thank him immensely and may God reward him abundantly.

I also acknowledge and appreciate Dr. Senait Ghebru, who accompanied me to the two schools during the process of gathering data for this research work and for her valuable comments, motivation and encouragement she demonstrated during the process. I also would like to thank Mr. Daniel Angaama for always being there to answer my questions. To other colleagues of mine in the office, I thank them all.

My special thanks goes to my younger sister Njideka Okonkwo (nee Okoroh) for her painstaking effort in proof-reading this manuscript and making all necessary corrections.

Finally, my unalloyed gratitude goes to my parents Prof & Mrs. O.V.N Okoroh, whose love for me has been incomparable. I am particularly grateful to my husband Moses Ubong-Abasi Okon and my son Prince Micah Okon, for their enormous patience, prayers, love, support and understanding during this research work. To my entire family members, I greatly acknowledge their love, care and spurs. May God bless them all.

DEDICATION

This piece of work is humbly dedicated to my lovely Son, Prince Micah Okon, who played a major role throughout the period of my studies, from the time of his conception, delivery and till now.

ABSTRACT

The clamour in the country about the poor performance of learners in the area of physical science is a concern and this problem had been attributed to different facets of learning which include the amendment of curriculum over the years. But my question is; can the curriculum amendment succeed without effective teaching approaches? This poignant question formed the central concern for this investigation. This study examined two cohorts of grade seven learners' conceptions of conservation of energy using a Dialogical Argumentation Instructional Model (DAIM) as well as the Traditional Lecture Method (TLM). The study involved 48 learners selected from two public schools in Cape Town. Using a quasi-experimental (Non-equivalent groups) design, the study examined the two groups from different schools (24 learners in each). It exposed one group to the Traditional Lecture Method (TLM) and the other group to a Dialogical Argumentation Instructional Model (DAIM) which was based on two argumentation frameworks– Toulmin's Argumentation Pattern (TAP) and Contiguity Argumentation Theory (CAT). The study lasted for a period of six weeks during which data was collected via Science Achievement Test (SAT), Idea about Conservation of Energy Questionnaire (ICEQ), Cloze Test (CT), Attitude to Science Questionnaire (ASQ), Classroom Observation, and Semi-Structured Interview. Data gathered were triangulated and analysed using qualitative and quantitative approaches. The findings show that (a) grade seven learners have an alternative conception on conservation of energy, (b) DAIM effectively enhanced the learners' understanding of conservation of energy and also, improved their attitude towards science, (c) no significant difference was found among the experimental group's (exposed to DAIM) conceptual understanding of conservation of energy, in relation to their age, gender, and language. Further implications and recommendations were presented in the study. Amidst all, it is recommended that all science subjects should be taught using DAIM for proper enhancement in learners' understanding of abstract concepts.

Keywords: Argumentation, Collaborative learning, Dialogical Argumentation Instructional Model, Toulmin's Argumentation Pattern, Contiguity Argumentation Theory, Teaching Natural science, Energy, Conservation of Energy, Conception, Intervention, Learners.

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ABBREVIATIONS USED IN THE STUDY

CAPS - Curriculum and Assessment Policy Statement

CAT - Contiguity Argumentation Theory

CCE - Conceptions of Conservation of Energy

CT – Cloze Test

DAIM - Dialogical Argumentation Instructional Model

DOE - Department of Education

DBE - Department of Basic Education

IASQ – Individual's Attitude towards Science Questionnaire

IACEQ- Ideas about Conservation of Energy Questionnaire

NCS - National Curriculum Statement

NSC - National Senior Certificate

SAT- Science Achievement Test

TAP - Toulmin's Argumentation Pattern

WCED - Western Cape Education Department

OPERATIONAL DEFINITIONS

Conception – A process of forming an idea with an understanding or belief about the nature of a given subject matter.

Alternative conceptions- Those interpretations, ideas, beliefs, and experiences that learners already acquired on their own and which seems contrary to targeted knowledge set out in the curriculum for science class.

Dialogical argumentation- An act of making a claim and using evidence to logically back one's position in a respectful way. It also involves people proposing alternative views, challenging the claims made by others, and finally coming to a consensus through convincing evidence.

Thought system - An opinion or idea that underlies many human actions and interactions, as well as understanding the existence and reality of a phenomenon.

Language of Instruction - The system of communication in which teaching and learning are presented in the classroom.

School science- The science that is taught and learnt at school using standard texts derived from European or Western science.

Energy (Amandla)- The capacity to do work. It is needed to make everything work, move or live.

CHAPTER ONE

GENERAL INTRODUCTION

1.1 Introduction

Science is a subject that deals with our day-to-day activities. It cuts across different aspects of our lives, our environment, society, and our knowledge about what happens around us. According to the Department of Basic Education (DBE, 2002), science is a study that is shaped by the search to understand the natural world through observation, codifying, and testing ideas, and has evolved to become part of the cultural heritage of all nations. It is a human activity that involves observing, representing, and investigating patterns and qualitative relationships in physical and social phenomena. It helps in developmental processes that enhance logical and critical thinking, accuracy, and problem-solving that will contribute to decision making. Natural science enables us to understand the world (physical, social, and environmental) around us, and most importantly; it teaches us to think creatively (Department of Basic Education [DBE], 2002).

Therefore, the teaching of natural science to learners has to deal with activities that motivate and venture into scientific literacy by ensuring proper knowledge and understanding of the scientific concepts among learners. The involvement of learners in such activities will captivate their interest, eagerness, and understanding, towards other scientific phenomena. The reason is that most learners tend to encounter difficulties in natural science because of its abstract nature and unless these are resolved early, they might find the subject and even the topic more difficult as they progress in their education.

Generally, most learners enjoy natural science when it deals with concrete objects but as they encounter more abstract problems later, they tend to give up and hate the subject. The challenge of course is that science, especially the senior phase of the physical science covered by the Revised National Curriculum Statement (RNCS) and the Curriculum and Assessment Policy Statement (CAPS), deals with a lot of abstraction or theoretical concepts such as the force of gravity, potential energy, kinetic energy, conservation of energy and so on. As a physical science teacher, I have noticed over the years that a large proportion of my learners usually perform very poorly on the conservation of energy. This is probably because they are unable to grasp the notion that energy is not destroyed but transformed from one form to another. This reality portrays the phenomenon of the existence and nature of the world we live in. It was against this background that this study attempted to determine the effectiveness or otherwise of a dialogical argumentation instructional model (DAIM) in enhancing the conceptions of conservation of energy held by grade seven learners in two Cape Town schools. DAIM like other argumentation instructional model (e.g., Erduran, Simon & Osborne, 2004; Osborne, 2010; Simon, 2008) has been seen to be effective in enhancing learners' conceptual understanding of diverse scientific concepts (e.g., Diwu & Ogunniyi, 2012; Ghebru & Ogunniyi, 2017; Hlazo, 2014; Ogunniyi & Hewson, 2008).

DAIM as an instructional paradigm was chosen among other teaching models because it has been found to be effective for facilitating conceptual understanding among learners (RuizOrtega, Tamayo & MárquezBargalló, 2015). Ogunniyi (2008, 2016) asserts that the interactive classroom arguments and dialogues help learners to acquire new perceptions and reasoning skills, think creatively, improve their knowledge, make an informed decision, obliterate alternative conceptions and perhaps even change their perceptions. Hence, my motive to adopt DAIM in this study.

1.2 Background of the study

Since 1993 when South African learners started to participate in the worldwide educational competition called Trend in International Mathematics and Science Study (TIMSS) the results have been generally low in comparison to other participating countries. Although the performance of the learners had improved after the implementation of CAPS, the expected target has not been achieved. More attention is still needed in the science subjects to bring our learners on par with students in other participating countries. According to Reddy, Visser, Winnaar, Arends, Juan, Prinsloo and Isdale (2016) TIMSS 2001 to 2011 indicates that 'the low international benchmark (400-475) students seem to have some knowledge of biology and to develop some familiarity with physical phenomena, however, slightly less than three-quarters of South African Natural Science learners scored below the international benchmark indicating that they do not seem to possess the basic Natural science knowledge required in the senior phase. The same low performance was demonstrated in 2015 by the South African grade nine learners who participated in TIMSS. Table

1 below shows the performance of South African learners against the international benchmark in 2015 TIMSS.

Table 1: South African International Benchmark Performance on TIMSS 2015

International Benchmark	Grade 5	Grade 9	
	Mathematics	Mathematics	Science
Advanced (>625)	1%	1%	1%
High (550-625)	4%	3%	4%
Intermediate (475-550)	12%	10%	9%
Low (400-475)	22%	14%	18%
Potentials (325-400)	28%	35%	28%
Not Achieved (<325)	33%	31%	40%

The proportion of learners who obtained Intermediate, High or Advanced international benchmark levels is worryingly low; 1% for both grade Nine Mathematics and Science; and 1% for grade Five Mathematics (Reddy et al., 2016). Incidentally, this outcome is similar to an earlier large study involving about 6000 grade 7-9 learners in the nine South African provinces (Ogunniyi, 1999).

Although, the National Senior Certificate 2017 revealed a 75.1% pass rate in the country, there are some indications of a drop in some subjects like physical science. Another issue, of course, has been the controversy surrounding scaling down the pass mark. The inability to get a 100% pass rate in sciences was narrowed down to poor teaching and learning of natural science at the foundation phase (Spaull, 2013). Some researchers have also indicated that learners fail science subjects due to some abstract and difficult concepts, like the aspect of force, electricity, and energy. Relating these problems to the learning that takes place at the foundation level, the researcher attempted to explore grade seven conceptions of conservation of energy (henceforth, CCE) among grade seven learners in two Cape Town schools by using DAIM as the teaching method.

1.3 Contextual Information

This study was conducted in two Cape Town schools, in the Western Cape Province of South Africa. Cape Town is located on the southwestern tip of the African continent, with coasts bordering the Indian and Atlantic oceans. It is the home to South Africa's oldest city, known as the "Mother City," and well-known for its tourist attractions. The predominant languages among the learners of the schools involved in the study are Afrikaans, English, and Xhosa. Specifically, the two schools chosen for the study share similarities in terms of the predominant Xhosa language, instructional resources, number of qualified science teachers, performance in annual national examinations in the last five years, and so on. Further details on this are covered adequately in chapter 3.

1.4 Rationale

Although natural science is critical to the socio-economic development of any country, it is a subject where learners tend to perform very poorly. As a result, the majority of the learners tend to show a negative attitude towards the subject. With my own experience as a teacher, I have noticed that these learners do very well at the foundation phase and early stage of the intermediate phase (grade 4, 5, and 6), but as they get to grade seven, the beginning of the senior phase, their interest starts to diminish gradually. Some of them pay much attention during teaching and learning, they tend to answer questions, but once an exercise is given for them to solve, they flounder miserably. The irony of course is that many of these learners have an occupational interest in becoming engineers, pilots, medical doctors, astronauts, to mention but a few science related careers. However, they shy away from their interest due to the notion that physical science is a difficult subject to study.

In line with this, the Department of Education (DoE, 2007) contends that more attention should be directed to the fundamental level at an early stage, as one way of addressing the problem of poor achievement, particularly to the final year performances which begin from Grade Seven Natural Science to Grade Twelve Physical Science.

1.5 Statement of the problem

There is a clamour in the country about the poor performance of learners, especially in physical science. However, if the foundation of knowledge in this subject is not well laid, failure is inevitable. On the other hand, if the foundation is firm, success is bound to occur. The lamentation of poor performance in this area of science portends grave consequences for the scientific human power development of the country. Performances in the national senior secondary school examination results have over the years been the yardstick that the country uses to measure its potential for scientific and technological human power and development. Students who perform poorly in Matric science are not eligible for admission to study the subject in higher institutions. For instance, some of the areas in physical science that learners perform poorly are photoelectric effect; electric circuit; momentum; work; energy, and power. The foundation for grade 12 physical science concepts like work, energy, and power are laid in grade 7 and some cases even in earlier grades.

Learners' negative attitude towards natural science is disturbing. It is important to state that often learning takes place in a sociocultural context-e.g., the learner's age, language, method and quality of instruction, curriculum goals, adequacy or otherwise of instructional resources, classroom atmosphere, etc. A plethora of studies has revealed that learners' poor performance in science is as a result of the difficulty they encounter in understanding the basic concepts taught in the classroom (Ali, 2012; Ngema, 2016). Others have also indicated that learners' inability to understand the foreign language of instruction is a major contributor to this problem (Brock-Utne, 2007; Msimanga et al., 2017). It has become glaringly clear that learning science a second language tends to confuse rather facilitate learners' conceptual understanding of what is presented to them in science. Furthermore, and in light of an examination-driven curriculum, learners are left with no option than to memorize scientific facts and concept e.g., the conservation of energy in the hope that some of what they have memorized might come up in the examination questions. This problem is further exacerbated by the fact that most teachers simply teach in order to cover the syllabus at a stipulated time for examination purposes. For this reason, they pay less attention to individual understanding and differences that exist among the learners during learning. In other words, they tend to believe that chorus answers to their questions implies learners' conceptual understanding. Likewise, they tend to ignore learners' socio-contextual differences and the consequences of such factors (e.g., Amineh & Asl, 2015; Banerji & Nanda, 2019; Purtell & Ansari, 2018; Rodriguez, 2016). Also, gender stereotypes in which females are treated and accepted to be inferior to males play a negative role in the performance of learners in the classroom (Kerkhoven, Russo, Land-Zandstra, Saxena & Rodenburg, 2016; Makarova, Aeschlimann & Herzog, 2019). It is this contextual realities that gives rise to the research questions.

Further, findings attribute these problems to poor curriculum development, learners' inability to learn, lack of qualified teachers, and teaching strategies (Makgato & Mji, 2006; Moodley, 2013; Musitha & Mafukata, 2018; Ngema, 2016). Some teachers claim over population of the classrooms and lack of consistent control during teaching.

The Department of Education (DOE) tried to address some of the findings mentioned above, through the amendment of curriculum over the years (Adu & Ngibe, 2014; Motshekga, 2010) but my question is, can curriculum amendment succeed without effective teaching approaches? This poignant question forms the central concern of this study. The main goal of the study is to determine the effectiveness of DAIM in enhancing grade seven learners' conceptions of conservation of energy (CCE).

1.6 Purpose of the study

The study seeks to explore conceptions of conservation of energy (CCE) among grade seven learners in two Cape Town schools. A corollary to this aim is to determine the effectiveness of a dialogical argumentation instructional model (DAIM) in enhancing their conceptions of conservation of energy. In pursuance of this aim, answers were sought to the following questions:

1.7 Research Questions

- What conceptions of conservation of energy (CCE) are held by grade seven learners in two Cape Town schools?
- How effective is DAIM in enhancing their conceptions of conservation of energy (CCE)?
- Are their conceptions of conservation of energy related to their age, gender, or language?

1.8 Theoretical Framework

This study is situated within constructivism because it is concerned with exploring and enhancing grade seven learners' CCE. The study is premised on the constructivist belief that no learner comes into the science classroom with a blank mind. However, what learners hold about a phenomenon may be scientifically invalid. The goal of constructivist instruction, therefore, is to determine what learners hold and then to take them to the stage where they can add the scientific knowledge to what they now hold. Furthermore, constructivist instruction such as DAIM attempts to find out the effectiveness or otherwise, argumentation instruction could help learners to expand their understanding of a natural phenomenon known as the conservation of energy which conflicts directly with learners' intuitive grasp of or experience with the nature of energy. Our general common-sense experience is that when we or systems use energy to perform some tasks, for example, to heat up some surroundings it is no longer available "to do more work for us" (see RNCS, 2002, p.68) or the systems concerned rather than being conserved in some other form. This also implies that the learners should be able to explain what they have learnt or to be able to practically apply the knowledge gained (Machaba, 2013).

Constructivism sees human beings "as active agents in their own learning" (Donald, Lazarus, & Lolwana, 2010, p.81). The idea is that knowledge is not passively received but actively constructed (Glasersfeld, 1989) through engaging in experiences, activities, arguments, and discussions which challenge the learners to make meaning of their social and physical environment (Ernest, 2010; Johnson, 2008). Children are actively engaged in building progressively more complex understanding of their world (Donald et al., 2010; Shcunk, 2004).

According to Moodley et al. (1992) constructivism emphasizes the active role of the child in constructing knowledge. The fact that the mind constructs knowledge means that our understanding will be limited by our perceptions. No wonder, learners have misconceptions about the conservation of energy, which are highly resistant to teaching. In other to replace misconception, we need to construct a new knowledge that is commensurate with our experience (Read, 2004) that is in line with the study of sociocultural theory (Vygotsky, 1978) which takes cognisance of our socio-cultural environment. It stresses the significance of socialization on individual learning (Kendra, 2017; McLeod, 2007).

According to Henning, Van Rensberg, and Smit (2004) a theoretical framework is a lens on which a researcher positions his or her study. It helps him/her to formulate the assumptions underpinning the study and how it connects with the world. It is like a lens through which a researcher views the world and orients his/her study accordingly. In other words, undertaking a study without a theoretical framework is like a ship pilot without a compass. In view of this, the present research intends to mobilize a dialogical argumentation instructional model (DAIM) to propel the discourses and the hands-on activities associated with the study.

DAIM is based on two argumentation frameworks namely, Toulmin's Argumentation Pattern (TAP) and Contiguity Argumentation Theory (CAT). DAIM in turn is underpinned by the contiguity argumentation theory (CAT) as espoused by Ogunniyi (2007a). TAP draws inspiration from Aristotelian inductive-deductive logic while CAT is informed by both Aristotelian and Ubuntu, a central African worldview theory. TAP is restricted only to logical arguments while CAT deals with both logical and non-logical culturally relevant arguments (Ogunniyi, 2007a).

CAT posits that when two distinctly different ideas come in contact with each other as often occurs when two cultures meet some conflict tends to emerge before they can accommodate each other possibly by seeking elements of commonalities, a point of correspondence or template through a form of dialogical argumentation or discourse with the ultimate goal of reaching consensus. CAT construes thinking as a process of self-conversation. The same process of self-conversation (intra-argumentation) can be extended to between two people or small groups (inter-argumentation) or even a large group (trans-argumentation) as in a classroom situation (Ogunniyi, 2007a, 2007b).

As indicated earlier, DAIM, as an instructional approach based on CAT, creates a learning situation whereby teachers and learners are actively involved in classroom discourses to reach collaborative consensus on a given issue. It allows learners to express their views freely, clear their doubts and even change their minds in the face of stronger arguments posed by others (Diwu & Ogunniyi, 2012; February, 2014; Ogunniyi, 2011). In other words, arguments provide learners ample opportunities to clarify their misunderstandings and to deepen their overall knowledge of a given subject matter (Hlazo, Langenhoven & Ogunniyi 2012; Ogunniyi & Hewson, 2008; Ogunniyi, 2007a).

DAIM is structured in a way that that argumentation begins within an individual even before sharing his/her view with others whether in a small or large group. In this regard, DAIM begins with individual cognitive tasks, then in a small group, and finally in a larger group such as a classroom. As learners work in small groups, they share their personal views while at the same time they are afforded the opportunity to learn from others what their viewpoints are. As a result of such interactions, their understanding of the tasks is greatly enhanced than would have otherwise been the case if they had worked alone (Ogunniyi, 2007a, 2007b).

CAT as espoused by Ogunniyi (2005) construes learning as a dynamic process, which influences an individual's mental state from one context to another. CAT unlike TAP addresses both the logical and the non-logical metaphysical arguments in that it explains both empirically testable facts as well as those not directly observable facts. CAT contends that a worldview that is dominant in a given context may become suppressed in another context or maybe assimilated into a more dominant worldview. At other times, a worldview may be emergent in that it is completely new to an individual or maybe exerting equal cognitive force on his/her point of view depending on the context in vogue.

1.9 Significance of the study

The central concern of this study was to explore grade seven learners' conceptions of conservation of energy. A corollary to this aim was to determine the effectiveness of a dialogical argumentation instructional model (DAIM) on their conceptions of conservation of energy.

It was hoped that the findings would be valuable to teachers as they seek for an effective way of conveying this concept to their learners. It was also hoped that the findings would provide additional information to aid efforts directed at helping learners overcome learning difficulties that might hinder them from studying physical science in higher grades.

It can be expected that if learners perform well in natural science early in life, they will develop positive attitudes towards the subject, thereby acquiring a high pass rate in the subject as well as achieve their desired career goals. It is hoped that DAIM would prove useful and informative for teachers desiring to involve their learners in the learning process than is usually possible under traditional classroom instruction where teachers tend to dominate classroom discourses. The outcome of the study could also create an insight into how science teachers' knowledge and skills could be greatly enhanced as they look for more effective ways to improve their instructional practices.

1.10 Literature Review

An adequate understanding of the concept of energy is taught in class to enable learners to assimilate the bond between other related concepts both in physics and other science subjects, thereby improving their scientific literacy. For instance, both the Revised National Curriculum Statement (RNCS) of the Department of Education (DOE, 2002) and the Curriculum and Assessment Policy Statement (CAPS) of the Department of Basic Education (DBE, 2011) for the Senior Phase, they construe energy as covering topics in both life and physical sciences which impact the people of South Africa.

The fundamental role of energy in physical science is reflected in the emphasis placed on the concept in science education at all levels (Heron et al., 2008). The stakeholders, teachers, and the general public agree that school teaching ought to equip learners with the expertise, capabilities, and talents needed to understand the dynamic world of technology that is growing with strength towards the use of energy (Duit, 1984). Generally, the teaching of energy is expected to introduce the physical energy concept and there are several issues related to this expectation. Despite this, however, there is still the issue of poor performance in the aspect of the energy concept, most especially conservation of energy. Therefore, a deliberate evaluation is needed to apprehend the solutions for a better understanding of the energy concept and facilitate expertise on how it is taught to learners and their understanding of it.

1.10.1 Conceptions of conservation of energy

Conservation of energy is one of the five basic aspects of energy that exists. The interrelationship of closeness between energy and conservation of energy makes it slightly difficult to separate the two, thus causing some misconceptions among learners. Herrmann-Abell and DeBoer (2011) indicated that students had more difficulty applying a general principle to a specific real-world case than they did in recognizing the truth of the principle itself. In related findings, Tatar and Oktay (2007) indicated that student's mistakes in the usage of energy can have a detrimental influence on their scientific comprehension of the energy conservation principle. Learners tend to express naïve views about energy conservation due to their prior misconceptions. Trumper, Raviolo and Shnersch (2000) stated that "misconceptions can also develop in situations where the scientific explanation of a phenomenon contradicts the initial or naive concepts that students have constructed based on their everyday experiences" (p.698).

Conservation of energy has in one way or the other been misunderstood or misinterpreted by both teachers and learners (Trumper et al., 2000; Ricardo, 2009). Likewise, the different instructional approaches that have been used have not had any significant impact on altering the misconceptions held by students (Goldring & Osborne, 1994; Nordine, Krajcik & Fortus, 2010). Opitz, Harms, Neumann, Kowalzik and Frank (2015) examined students' conceptual understanding of four aspects of energy. Their findings showed that the learners scored highest on items for energy forms but the lowest scores and the smallest gains across grades were found for the conservation of energy. Learners' misconceptions of the conservation of energy have consistently proved difficult to teach and learn and hence the need to explore other instructional strategies such as argumentation instruction which forms the central concern of this study.

From the foregoing, the present study aimed at exploring grade seven learners' conceptions of the conservation of energy because as indicated earlier, it is an aspect that tends to create confusion in the minds of most learners. Although there have been problems in the conception of energy in different stages of teaching and learning, many studies have indicated that the idea of energy is a hassle for a considerable number of teachers.

According to Herrmann-Abell et al. (2011) research on students' understanding of energy transformation, energy transfer, and conservation of energy show differential levels of understanding, but the most difficult of these concepts perhaps is the conservation of energy and its application to specific real-world experiences. Ricardo (2009) argued that physicists have pointed out that we do not know what energy really is. If there is no clear idea of energy, teaching the concept must be a problem and that is why grade seven learners need to have a clear understanding of this concept from the earlier grades otherwise they would carry their misconceptions to the higher grades.

Some researchers contend that learner's backgrounds (e.g., age, gender, or language) and experiences contribute to their misconceptions about the conservation of energy (Çoker, Çatlıoğlu & Birgin, 2010; Tatar & Oktay, 2007). But whatever the differences in their backgrounds, they all need to develop valid conceptions of the concepts. Duit (1981) suggests that most students preferred conceptions and notions stemming from everyday experiences. He stresses that energy should not be restricted to the ability to do work, in that the common way of construing energy via work tends to create severe learning difficulties.

This indicates why appropriate instructional emphasis should be explored to the conservation of energy. As Haron, Michelini and Stefanel (2018) have contended the development of an instructional approach on the nature of energy, is both scientifically and developmentally challenging. Moreover, the traditional approach taken at the university level involving mechanical work has many prerequisite concepts that are themselves difficult to teach young students. Nevertheless, early learning of conservation of energy with an appropriate teaching approach could form the basis for a deeper understanding of the concept among learners in later school life (Opitz et al., 2015). See more details in chapter two.

As a way to find an effective instructional approach to enhance the concept- energy to grade seven learners, the study explored the potential of DAIM for exploring and enhancing the grade seven learners' conceptions of conservation of energy. As indicated earlier, argumentation instruction (Erduran, Simon & Osborne, 2004; Simon & Johnson, 2009) has been found generally to enhance conceptual understanding. For example, DAIM has been shown to facilitate the valid conceptions of diverse scientific concepts (Diwu & Ogunniyi, 2012; Ghebru & Ogunniyi, 2017; Hlazo, 2014).

In view of this, I have also decided to determine the veracity of DAIM among grade seven learners relative to their understanding of the conservation of energy. If this assumption is valid then one would be confident to recommend it to other researchers in the area. The study was intended to be an effective and meaningful intervention that could help eliminate misconceptions that learners hold relative to diverse natural phenomena (Diwa, 2010; George, 2014; Hlazo, 2014; Riffel, 2013). As shown in Figure 1.1 DAIM is consisted of different stages.

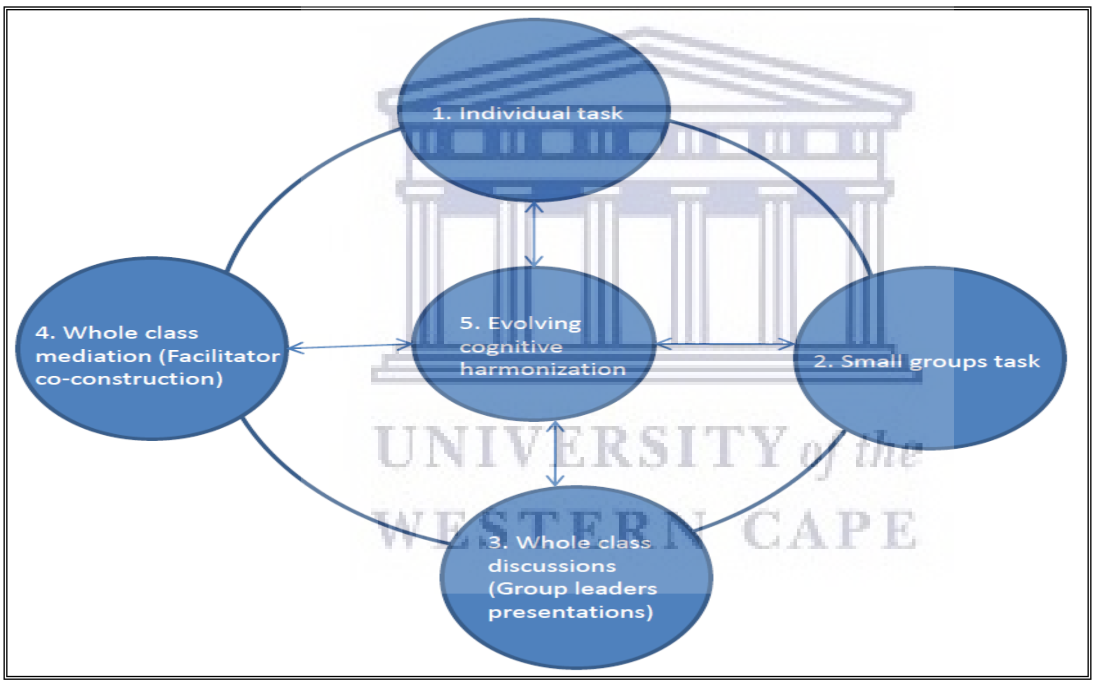


Figure 1.1. Stages of DAIM as espoused by (Kwofie & Ogunniyi, 2011; Ogunniyi, 2009)

The stages in the dialogical argumentation instructional model above show the process in which learners become deeply involved in the instructional process and thereby express their thoughts, clear their doubts, and change their views. Ogunniyi (2009) contends that DAIM is an instructional strategy that can be used in the science classroom to permit learners to externalise their views besides those of school science. The process of starting from an individual task, then to the small and lastly the large group task enables each learner to gradually develop a deeper understanding of the concept in question regardless of their age, gender, or language (I will elaborate on this more in chapter 2).

1.11 Delimitation

According to Simon (2011) the delimitations are those characteristics that set the scope and define the boundaries of a study that the researcher can control. Taking into consideration, this study focuses mainly on the conceptions of conservation of energy among grade seven learners in two Cape Town Schools in Western Cape, South Africa. In order to set a clear boundary, grade seven learners from one of the schools were chosen as the experimental group and the grade seven learners in the second school were used as the control group. This study adopted a quasi-experimental design (Non-equivalent design). Toulmin's Argumentation Pattern (TAP) and Contiguity Argumentation Theory (CAT) was adopted as the theoretical framework. Hence, the findings of the study are not generalized to the other grade seven learners in other schools in the province.

1.12 Summary

The introductory chapter draws attention to how poor performance in science could be as a result of the conceptions learners incorporate in different scientific concepts. This tends to create a barrier in learners' clear knowledge of science as a subject and not necessarily the curriculum itself. Research findings in different regions of the world have shown that learners generally encounter great difficulty in mastering diverse abstract scientific concepts. Among these concepts, conservation of energy has been found to be notoriously difficult for most learners regardless of age, gender, or culture. It was in pursuance of attempts to find a solution to this problem that I embarked on the present study. An innovative teaching approach known as DIAM was employed to explore grade seven learners' conceptions as a way to direct their thought towards developing a valid understanding of the concept. In pursuance of this aim, more details and insight regarding the study have been provided in subsequent chapters.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The teaching and learning of energy especially the conservation of energy had been a major concern at all levels of science education, due to inadequate conception of the concept at the foundation level (Heron, Michelini & Stefanel, 2008). Conservation of Energy is an aspect of science that is embraced by the only law governing the entire natural phenomena known as the law of conservation of energy (Feynman, 2013). However, there have been different views on the understanding of this concept as well as the teaching approach relative to the use of appropriate scientific terms and also the learners' intuition towards the concept.

This chapter will explore in detail some theoretical and practical considerations. More specifically, the chapter would present the theoretical framework underpinning the study particularly the application of a Dialogical Argumentation Instructional Model (DAIM) in a classroom setting. As indicated in chapter one. DAIM is premised on two theoretical constructs namely, Toulmin's (1958, 2003) Argumentation Pattern (TAP) and the Contiguity Argumentation Theory (CAT) (Ogunniyi, 2007a, 2007b). A review of these terms will bring to light the value of DAIM in this study.

2.2 Energy as a concept

Conservation of energy had been a concept that cannot be explained without first emphasizing the concept of energy. In fact, whenever a new topic or concept is introduced by a science teacher, the concept ought to be defined (Lehrman, 1973). Therefore, Energy is the aspect of science that draws more insight into the conservation of energy. Energy had been a concept we hear about everywhere and every day. This is because it is one of the broad topics that evolve every aspect of our lives, both observable and non-observable aspects. It also cut across several disciplines in science. This made the generality of much published research on this issue problematic (Barbosa & Borges, 2006; Lehrman, 1973; Tatar & Oktay, 2007).

However, the learners' natural science textbooks we use today, for example, Platinum Natural Science which is in use in all primary schools in Western Cape province and recommended by the Western Cape Department of Education (WCED) with guidelines from the Curriculum and Assessment Policy Statement (CAPS) defines "Energy as the ability or capacity to do work" (CAPS Platinum, 2013, p.125). Although recent, works of literature in the field of science contradict this definition and refer to it as wrong and misleading thereby contending that it did not truly define energy (Barbosa & Borges, 2006; Goldring & Osborne, 1994; Lehrman, 1973; Sefton, 2004; Serway & Jewett, 2014; Tatar & Oktay, 2007).

However, Sefton (2004) contend that in actual fact there was no unique, absolute, or universal concept of energy and it has no simple or holistic definition (Azzuni & Breyer, 2018) because more ideas about energy are still developing and cropping up in new contexts which can contradict the old ideas in conformity that "energy present in the universe were of various forms" (Serway & Jewett, 2014, p.177).

Similarly, Walker's (1996) study demonstrated that the definition of energy as the capacity to do work implies energy to be a more abstract concept than work and concluded that the concept was incomplete. Walker further defined "Energy as a property of matter that can be converted into work, heat or radiation" (p.8). This definition might as well lead to more logic but in line with this study, it gives a clearer insight into the understanding of the law of conservation of energy.

In fact, the definition of energy as the capacity to do work depicts a clear description of energy for grade seven learners at that fundamental level of learning (see RNCS, 2002, p. 66). In accordance with that Heron et al. (2008) contend that the "fundamental role of energy in physics were reflected in the emphasis placed on the concept in science education at all levels and without a quantitative interpretation, the concept becomes meaningless" (p.1). Therefore, Energy as the capacity to do work was accepted to be relevant in commensurate to grade seven learners' level of understanding. More so, describing energy as work unfolds the close interrelationship between energy and conservation of energy which makes it impossible to discuss one without another (Goldring & Osborne, 1994). This seems better because energy (Potential Energy) most undergo a work (Kinetic Energy) before it would be converted into another form.

In accordance with the above explanations, Tatar & Oktay (2007) affirm that learners' conceptions and alternative conceptions about conservation of energy stem from preliminary explanations about energy concepts in our daily life. These ideas draw our minds to certain contradictions that take place during teaching and learning of conservation of energy. However, the evidence for this relationship was inconclusive to the main study on conceptions of conservation of energy among learners.

2.2.1 The understanding of conservation of energy

Conservation of energy had been an important law in physics that simply states that "energy can neither be created nor destroyed but can be transformed from one form to another" (CAPS Platinum, 2013, p.125; Helmenstine, 2018). It is a principle that describes the energy in an isolated system (Hilbert, Hänggi & Dunkel, 2014) regardless of any internal changes that may take place with energy disappearing in one form, it will resurface in another form. This simply implies that everything that happens in the universe obeys this fundamental law (Woodford, 2017) but the comprehension of these phenomena with the inscription 'can neither be created nor destroyed' seems to be a debatable aspect for learners to apprehend.

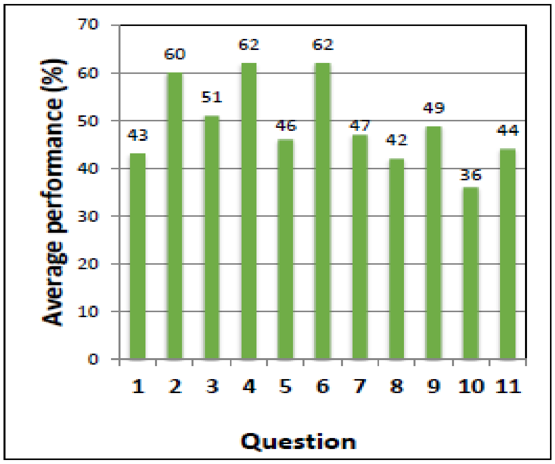
This brings us back to the actual definition of the law of conservation of energy. For many years, different science textbooks we used and still using stated the law of conservation of energy as 'energy can neither be created nor destroyed but can be transformed from one form to another'. This sounds unrealistic when given a reasonable taught within the natural course of the event, hence exploring further investigations, it was discovered that around the year 1900, a physicist named Max Plank devoted his life to the study of the laws of thermodynamics. He stated that 'energy is conserved; it cannot be created **from nothing** and cannot be destroyed…' (Cline, 1965). This statement makes it clearer and understandable that energy cannot be created out from nothing. However, there had been several longitudinal studies involving learners' understanding of conservation of energy that were reported unsatisfactorily in terms of their performance in the conception of the phenomena.

A survey such as that conducted by Herrmann-Abell and DeBoer (2011) used standards-based multiple-choice assessment items to study students' understanding of ideas about energy transformation, energy transfer, and conservation of energy. The data was collected using 9739 middle school students and 5870 high school students with Rasch modelling. The findings indicated that students had the most difficulty with items aligned to the idea of conservation of energy. The study further reported that students experience difficulty in most cases when applying a general principle to a specific real-world case than they did in recognizing the truth of the principle itself.

Similar to that Opitz et al. (2014) investigated students' progression in understanding the energy concept in biological contexts. It was assessed along with four aspects of energy: (1) forms and sources of energy, (2) transfer and transformation, (3) degradation and dissipation, and (4) energy conservation. Using a quantitative approach among grade 3-6 learners (N=540), their findings indicated that students were observed to progress in their understanding of all four aspects of the concept, and the lowest scored across all the grades were found in the conservation of energy.

In accordance with the above, Dalaklioğlu and Şekercioğlu (2015) study investigated grade eleven high school learner's difficulties and misconceptions about Energy and Momentum concepts. They administered multiple-choice questions to a population sample of 284 learners. Analysis of results showed that the learners had many misconceptions related to momentum and energy concepts mostly with applying and connecting relationships between the conservation of energy and momentum in any given situation.

However, these findings were not far from South African national senior certificate schools' performance, as shown in (Figure 2.1); how the diagnostic statistical analysis of learners' performance in physical science 2017 matric. The figure depicted low performance in question 5 which deals with work, energy, and power. Challenges that learners faced in tackling questions about the conservation of mechanical energy resulted in their poor performance.



Q1	Multiple choice questions - all topics
Q2	Newton's laws of motion
Q3	Vertical projectile motion
Q4	Momentum
Q5	Work, energy, and power
Q6	Doppler effect
Q7	Electrostatics (Coulomb's Law)
Q8	Electrostatics (Electric Fields)
Q9	Electric circuits
Q10	Electrodynamics: Motors, generators and alternating current
Q11	Photo-electric effect

Figure 2.1. The relative degrees of the challenge of each question as experienced by candidates (Modified from DOE, 2017). Source: (Department of Education Science Diagnostics, 2017)

Question 5 which deals on Work, Energy, and Power indicated some misconceptions and use of incorrect answers as learners were confused about questions applicable to the conservation of mechanical energy.

The few outlined findings indicated a gap in learners' understanding of the conservation of energy compared to other aspects of energy. This an indication that students' understanding of conservation of energy might be influenced by either vocabulary used in stating the law or different factors which could come from the definition of energy as 'ability to do work' and their everyday experience in the use of energy in human activities, or their world view, which seems to contradict with the scientific contexts and the pedagogical impact during learning (Jin & Anderson, 2012; Opitz et al., 2014; Sefton, 2004).

It could be noted that once a proper understanding is lacking there could be an alternative conception and in most situations, the learners themselves think they know exactly what the teacher is talking about and they end up holding onto their worldviews. This manifests or unfolds when a task is given to the learners and the outcome appears negative. This had portrayed a kind of observation and self-taught which seems to reflect some notions of doubt in having a clear comprehension of the concept, considering the constructivist view that all learning is built on prior knowledge (Sefton, 2004; McLeod, 2014).

Emphatically the term ‘conservation’ had been used in natural science to describe energy in two contradictory ways. Some observers (Raphoto, 2008; Sefton, 2004) had already drawn attention to the paradox in the use of ‘conservation’. Sefton (2004) argued that the key emphasis of the energy concept was ‘conservation’ that without conservation, the concept of energy would not be meaningful.

In accordance with the above, the use of conservation in two different ways to explain energy could have some effect on learners’ conceptions of conservation of energy. Having in mind that the use of words plays a significant role in our communication and language as the key mediator of meaning between individuals could by the same token be a source of miscommunication and can cause internal cohesion (Rudvin & Spinzi, 2015).

However, the term conservation means saving energy and not wasting it (Eskom, 2018) which means to use energy more efficiently and not to waste it. This meaning had been continually reinforced on social media and in advertisements. An example is the expression, “saving electricity,” which is often used by Eskom, the suppliers of electricity in South Africa.

On the other hand, conservation involves energy change that converts energy into different forms which made energy impossible to be neither ‘created nor destroyed’. This seems to create more confusion among learners when conservation of energy is taught in class as either being ‘conserved' and ‘cannot be destroyed’. These live learners with some possible questions such as: ‘if energy cannot be destroyed, why is it always used up’? Where does the energy go after being used up? We use energy to do work and gain strength to accomplish a task. In common experience, the energy once used is gone forever.

2.2.2 Alternative conceptions of conservation of energy

Alternative conceptions are those interpretations, ideas, beliefs, and experiences that learners already acquired on their own which contradict targeted knowledge set out in the curriculum for science class (Dega & Govender, 2016; Smolleck, 2011). However, alternative conceptions had been a long existing factor among learners, but many researchers have argued that inadequate or alternative conceptions have a strong effect that might hinder learners understanding of scientific concepts (Govender, 2011; Ogunniyi & Taale, 2004; Osborne & Freyberg, 1995; Raphoto, 2008; Rankumishe, Raphoto & Maimane, 2014).

Some researchers (Posner, Strike, Hewson & Gertzog, 1982; Rankhumise & Lemmer, 2008) contend that it is difficult for teachers to change the learners' persistent held alternative conception irrespective of any formal instruction unless a new intelligible idea superior to the former emerges. The superiority of the intelligible idea should be made known by learners by providing them with concrete evidence. Although, Govender (2011) study argued it is extremely difficult to achieve conceptual change; especially in concepts that had everyday experiences that do not match abstract scientific thinking. This does not seem convincing to this present study because certain factors need to be put into consideration before such a conclusion could be drawn for example; one needs to consider the teaching approach implemented, what was the duration of teaching, what time of the day was it taught, how much did they know about the learners learning skills, etc. All these have to be considered before changing a learner's alternative conception. If not, what effect does alternative conception have on the learner if there is no alternative way to apprehend it so that a proper understanding of the scientific concept can take place?

Considering the fact that, the abstract nature of the concept of conservation of energy made it more prone to different alternative understandings. It was widely argued and recommended on the importance to diagnose learners' alternative conceptions in a topic before teaching, and then explicitly challenge them and modify their knowledge in appropriate ways (Coetzee & Imenda, 2012; DOE, 2002; Franke, Scharfenberg & Bogner, 2013; Sefton, 2004; Taker, 2015).

Ogunniyi et al. (2004) study confirms that though it might be difficult for learners to become dissatisfied with their own worldview in favour of the scientific worldview, he argued that a quality instructional model could be used to impart these concepts to learners. Detailed examination of Ogunniyi's (2007) study explained how two or more competing thought systems that emerge in a learning situation could be solved or suppressed after presented with empirically testable evidence. Hence, this study seeks to apply that quality instructional model by Ogunniyi known as the Dialogical Argumentative Instructional Model to find out the conceptions learners in grade seven hold for the conservation of energy and if Dialogical Argumentative Instructional Model (DAIM) could effectively serve as a quality instructional model in this study.

2.3 Learners' thought and perception (Thought system)

Drawing on Ogunniyi's (2007, 2016) contiguity argumentation theory (CAT) and dialogical argumentation instructional model (DAIM), it became necessary to discuss a thought system in the context of learners' worldviews and interaction as pertaining to conservation of energy. Thought is a common phenomenon that exists in the human mind. Thought repeatedly interprets phenomenological existence from a subconscious state into a conscious state of mind in a given situation. Therefore, thought is described by Harman (2015) as a character of the mental state formed by belief, desire, idea, notion, perceptions, etc that is expressed within the mind. However, learner's thought determines their representation, interpretations, and predictions of their worldviews and experiences.

According to the Revised National Curriculum Statement (RNCS, 2002) description of worldviews expressed that "people tend to use different ways of thinking for different situations, and even scientists in their daily lives may have religious frameworks or other ways of giving value to life and making choices" (p.12). The reflection of the worldview which I relate with the thought system in this study could bring about different opinions about the conservation of energy among learners. As Redish (cited in Iwuanyanwu and Ogunniyi, 2018) affirm that "every person's thinking process is largely shaped by being raised in a particular culture and that could determine the way he/she processes experience and responds in a particular predictable manner" (p.289). The learners' opinion produced by their thinking could emerge as a result of their different belief system, custom, native background as well as their thought in line with their experience.

In accordance with the above, the Department of Education (2002) also noted that one can assume that learners in the field of Natural Sciences learning areas think in more than one worldview. "Several times in a week they cross from the culture of home, over the border into the culture of science taught in a different language, and then back again, hence it could influence their understanding of science" (Ogunniyi, 2004, p.291). Most times learner's thoughts and perceptions become astounded during classroom discussions. Therefore, teachers need to clarify their thoughts and understanding about everyday experiences associated with scientific content being taught. Also, teachers should discover learners' perceptions on each topic before teaching to enable a proper understanding of the concepts among learners.

2.3.1 Age and scientific influence

Age is a chronological stage at which human characteristics vary over time (Rodriguez, 2016). Age had been a vital issue within the educational system and school enrolment policies in both South Africa and beyond. In most schools, all grades were expected to represent a given age, as a result, the curriculum, teaching materials, and teaching methods (including language) vary according to their age with the assumption that each group has similar educational needs. Although in most classrooms some learners were found to be older than their counterparts and some of them could be repeaters in most cases. Amidst that, teaching and learning were assumed to be carried out in other to accommodate all learners.

However, some researchers argued that age differences in a classroom affect learners' performance in learning since their performance evaluates their conceptual understanding of any subject content. It was argued that learners' age significantly influences their ability to learn, though they become more attentive as they grow older (Momanyi, Too & Simiyu, 2015; Thoren, Heining & Brunner, 2016; Ünal, 2019). On the contrary, Imlach's (2017) research findings contend that age did not influence learning and understanding.

Amidst other learning challenges, a higher number of researchers had reported the relative age effect that conveys poor performance among the younger learners compared to their older classmates (Fortier, 2017; Joseph & Lacobe, 2019; Ünal, 2019). A conducted study by Bernardi

(2014) indicated that younger learners face a higher risk of grade repetition as a result of poor performance compared to their older counterparts. Similarly, Horstschraer and Muchler (2014) indicated that regulating school entry creates disadvantages for relatively younger learners, hence the difference in their performance served as a disadvantage to young learners compared to their older classmates. Also, a study conducted by Ünal (2019) in finding out the impact of relative age effect on 2015 TIMSS fourth and eighth grades mathematics scores indicated that relative age has an impact on TIMSS 2015 fourth, and eighth grades mathematics score and the youngest children born just before the cut-off date had the worst performance.

On the contrary, Momanyi et al.'s (2015) research on the effect of learners' age on academic performance significantly indicated that the youngest learners outperformed their older classmates. Therefore, this study investigates grade seven learners' conceptions of conservation of energy relative to their age.

2.3.2 Gender differences

Gender differences have been generally viewed as a significant variable and a crucial area to be considered while engaging learners in a quality scientific study. This is because of its relatedness towards learners' attitudes to science (Hacieminoglu, 2016; Osborne, Simon & Collins, 2003; Weinburgh, 1995). Although, Rivard and Straw (2000) stated that gender and ability were important mediating variables that determine the effectiveness of talking and writing that enhance learning. However, Anggoro, Sopandi and Sholehuddin (2017) affirm that the key in concept mastery among learners depends on their attitude, understanding, and interest.

A considerable number of studies have shown the importance which educators attach to gender differences in learners towards their perception of a scientific phenomenon and then build upon that knowledge with an effective instructional approach and implementation strategies of teaching (Sousa, 2011; Osborne, Simon & Collins, 2003). Although, what one can deduct from such studies was that gender differences in conceptions of scientific phenomena were largely based upon empirical studies most of which claim that males are generally more favourably disposed to science than females. They also seem to suggest that males show better participation, achievement, and interest in science classrooms than their female counterparts. Nasser (2016) study also shows that "gender makes a difference in cognition in elementary schools" (p.9).

The gender difference was further emphasised to have been disposed among males in areas of interest, mode of interaction, discussions, level of understanding, and involvement in science classes (Mogari, 2010; Osborne, Simon & Collins, 2003; Reddy, 2017; Saxena & Rodenburg, 2016) and this, in line with other social issues enhance their scientific understanding with a high rate of performance in school science (Mogari, 2010). An earlier study by Weinburg (1995) indicated that among average learners' males held a more positive attitude towards science than their female counterparts. Younger, Warrington and Williams (1999) also affirm that males dominate most science classroom learning interactions.

In search to explore more, some researchers attribute certain factors towards the above mentioned findings as a result of environmental influence, teaching methods, biological, neurological or brain structure, cognitive development, and cultural stereotype as causes for gender differences (Bonomo, 2010; Gurian, & Stevens, 2006; Mogari, 2010; Sousa, 2011). On a contrary, some researchers argued that the performance gap was exaggerated and imaginary as Newman-Ford, Lloyd and Thomas (2009) declare that gender has only a slight influence on learners' academic achievement while Patrick, Mantzicopoulos and Samarapungavan (2009) affirm that early meaningful teaching, motivation, and participation of boys and girls in science learning promote their interest in science.

It is equally interesting to indicate that 21^{st}-century female learners do not necessarily entertain gender dominance by boys. Prior to my experience as a teacher, I have observed that most female learners outperform and outshine their male counterparts in classrooms. In accordance with Ayano (2018) study on the influence of learners' age, language, and gender issues on their understanding of certain scientific concepts and the findings indicate that the girls seemed to have better conceptions of scientific concepts than the boys. However, as the case may be, this present study tends to investigate whether learners' conceptions of conservation of energy were in relation to their gender.

2.4 Dialogical Argumentation Instructional Model (DAIM)

DAIM is used as a platform where learners are exposed to the nature of argumentation and the way it is used to resolve disagreements and controversies within a scientific belief/thought practice (Ogunniyi, 2016).

The dialogical argumentation instructional model had been widely declared as a teaching tool for resolving conceptual conflicts in science education. Some studies such as that conducted most recently by Ogunniyi (2018) explored the effect of a Dialogical Argumentation Instructional Model on the educators' conceptions of the nature of science (NOS). The study involved 18 educators in a series of lectures on the history, philosophy, and sociology of science for three hours per week for six months. Data was collected using a questionnaire, interviews, and reflective essays and the findings indicated a significant difference. Hence, educators shifted from their naïve view of science as a body of infallible truths about nature, whose path is known, to considering science as a tentative, dubitable, and revisionary inquiry.

Similarly, Nuryandi (2016) applied DAIM to determine the high school students' understanding of static electricity in Majalengka Regency (Indonesia) by using a quasi-experimental design. The results showed a shift in the student's conception of the concept, from an average score of 30.16% to 72.81% with a percentage value of N-gain of 61.36% in the medium criteria and an increase in the ability of students' argumentation from the average score of 27.12% to 72.07% with an N-gain value of 62.01%. There seemed to be a significant difference in the study.

Correspondingly, Philander and February (2016) investigated the effect of the Dialogical argumentation instructional model (DAIM) on grade three learners' understanding of how water and water pollution affect human welfare. The study was based on a quasi-experimental research design and collected data using a qualitative and quantitative approach with a sample of 38 grade three learners within the age bracket of 7-9 years old from a primary school in Cape Town. The findings also revealed a significant cognitive shift in learners' understanding of the causes and effects of water pollution.

George (2014) used a similar procedure and explored the Dialogical Argumentation Instruction (DAI) approach to determine whether it would enhance grade ten learners' understanding of the chemical equation concept. 50 learners participated in the study: 25 each for both the experimental and the controlled groups. The study employed a quasi-experimental design and adopted a mixed method approach. However, the findings showed a significant difference between the experimental group control group suggesting that Dialogical Argumentation Instruction was an effective and meaningful intervention and helped to eliminate misconceptions during the study.

Furthermore, Ogunniyi (2016) attempted to determine the effect of the Dialogical Argumentation Instructional Model in enhancing the participants' awareness about the cultural and educational value of an indigenized science-IK curriculum in the classroom context. The findings showed that DAIM was effective for; (a) engendering the participant's sense of collectiveness and responsibility in finding ways to resolve conflicts or solve a problem; (b) facilitating their awareness about the potential argumentation instruction in classroom discourse; (c) enhancing their understanding of the nature of science (NOS) and IKS (NOIKS); (d) fostering their positive views about the new indigenized curriculum (e) facilitating their emergent understanding about NOS and NOIKS; f) increasing their awareness of IK as a legitimate way of knowing and interpreting experience in science. This took effect after involving 23 science teachers and science educators who were exposed to an Ubuntu-based dialogical argumentation model (DAIM) for a period of two years. Data were derived from video-audio-recordings and interviews.

Aydeniz, Pabuccu, Cetin and Kaya (2012) conducted a similar study using an argumentation-based pedagogy to explore college students' conceptual understanding of properties and behaviours of gases. A sample of 108 students (52 in the control group and 56 in the intervention group) were drawn from 2 general chemistry college courses taught by the same instructor. The result indicated a significant difference. The most interesting part was that 80 % of the students in the intervention group abandoned their initial ideas on all of the 17 alternative conceptions that were identified by the authors but one. The percent of students abandoning their initial ideas in the control group was less than 20%.

Also, Ghebru and Ogunniyi (2018) further investigated challenges that science teachers usually face in their attempts to implement an argumentation-based instructional model (ABIM) in science classrooms by examining Pre-service Teachers' perceptions of argumentation instruction as well as their motivation for using such an approach. A cohort of 25 pre-teachers from the institute of higher education in Eritrea was involved in the study. A significant difference was recorded as follows; 1) the pre-teachers held a positive attitude towards the use of argumentation instruction; 2) they were highly motivated to use the approach in their instructional practices, and 3) they provided various reasons for wanting to implement argumentation instructions in their classrooms.

Moreover, Iwuanyanwu and Ogunniyi (2019) conducted similar research that examined the challenges the pre-service teachers face in developing conceptual resources needed to solve science problems in classical mechanics. Forty first-year pre-service science teachers were exposed to problem solving skills using a DIAM approach. Physical Science Achievement Test was used to collect data and findings showed that the experimental group significantly outperform the control group counterparts on problem solving classical mechanics.

Also, several studies have been carried out on science and indigenous knowledge in Africa. For instance, many articles emanating from the Science and Indigenous Knowledge Systems Project (SIKSP) have been reported in conference proceedings and journals (e.g., Diwu & Ogunniyi, 2012; Ogunniyi, 2007a & b; Ogunniyi, 2016; Riffel, Langenhoven & Ogunniyi, 2013).

The above outlined studies showed that DIAM as a teaching model has a great influence and enhances both teachers' and learners' performances at different levels of learning hierarchy in resolving conceptual conflicts in science education. Accordingly, one may ask, what then is this argumentation approach, applied in the above studies that brought about a comprehensive significant change? It was on the basis of considering this preceding, that the potential of DAIM emerged.

2.4.1 Argumentation

The word 'argument' has been in existence for centuries. Its existence was a common practice among people both young and old. An argument had been literally seen as a form to prove a point during a disagreement, quarrel, an exchange of views, opinions, disputes, etc, a normal lifestyle that involves verbal and body communication among two or greater number of people. A common phenomenon that prompts among different individuals, group of people, young and old in a normal everyday discussion in which human beings tend to defend their beliefs, norms, and private interests or decide to change them, after an affordable communication, up to a point in a process of communication (Kuhn, 2010).

The existence of this phenomenon prompted ancient Greek prominent philosophers like Aristotle, Plato, Socrates to investigate and researched more on 'arguments', their findings embedded more on practical reasoning, logic, epistemology, and rhetoric (Erduran, Ardac & Yakmaci-Guzel, 2006; Ghebru, 2014; Lee, 2014; Ogunniyi, 1992). Subsequently, different fields of study started to rely on the use of argumentation especially in the field of science. Many practitioners and researchers came up with different definitions and views about argumentation.

As time progresses, numerous studies attempted to explain argumentation towards a reasonable and acceptable idea to knowledge. Lewiński and Mohammed (2016) defined argumentation as a communicative activity of producing and exchanging reasons in the context of doubt or disagreement. Others define argumentation as a process of thinking and social interaction in which individuals construct and critique arguments (Golanics & Nussbaum, 2008; Nussbaum, 2011). In a similar vein Eemeren, Grootendorst, and Snoeck (1996) construe argumentation as a verbal and social activity of reason aimed at increasing (or decreasing) the acceptability of a controversial standpoint for the listener or reader, by putting forward a constellation of propositions intended to justify (or refute) the standpoint before a rational judgment.

According to Toulmin (1958) argument was seen as a product of dispute between people- a process view that stresses the interactive context in which an argument emerges. In a social activity, individuals who hold contrasting positions attempt to convince each other of the acceptability of each adopted opinion. It refers to the substance of claims, data, warrants, and backings that contribute to the content of an argument. Argumentation refers to the process of assembling these components.

In accordance with that Ogunniyi (2007) elucidated "argumentation as a statement or constellation of statements advanced by an individual or a group to justify or refute a claim in order to attain the approbation of audience or to reach consensus on a controversial subject" (p.965).

The above definitions have a common idea towards solving a problem within a social setting (Kuhn, 2010) through claim making, reasoning, thinking, and critical evaluation of evidence which brings about clarifications and conceptual understanding of a given phenomenon (Erduran, Simon & Osborne, 2004). Science itself often progresses through a dispute, conflict, and argumentation rather than through general agreement (Kuhn, 1962; Latour & Woolgar, 1986). Thus, arguments concerning the appropriateness of experiments, interpretation of evidence, and the validity of knowledge claims are at the heart of science and are central to the everyday discourse of scientists. Scientists engage in argumentation and it was through this process of argumentation within the scientific community that quality control in science was maintained (Kuhn, 1992).

These shed more light on how scientific argumentation becomes quite different from our daily arguing that goes on between people rather in scientific argumentation explanations are generated, verified, communicated, debated, and modified (Llewellyn 2013; National Research Council [NRC], 2012). The claim making denotes the idea of presenting factual information in a social setting, based on observable evidence that clarifies a claim through the justification of the evidence (NRC, 2012).

Then, thinking and reasoning in this context connote rational reasoning that involves intelligence. As Kuhn (1992) described thinking as an argument that describes real world intelligence, and the extent a process of argument can reach to determine the higher level of thinking and also the level of belief they hold and their opinions they espouse about important social issues. Therefore, the classroom is an interactive forum for practicing and improving argumentative discursive and thinking skills (Kuhn, 1992). The argumentation in this discussion focuses on classroom teaching and learning of a science concept known as the conservation of energy.

However, the learners will be exposed not only in reasoning and thinking but would be actively involved in reading and writing arguments as well as identification of claim, evidence, warrant, and counter-claim made by others in a given task which as a whole bring cognitive and social perspectives to argue (Newell, Beach, Smith & Van Der Heide, 2011).

2.4.2 Argumentation as a teaching approach among young learners

A large and growing body of literature has investigated science teaching and learning as a means of informing how scientific knowledge can be taught and learnt using argumentation (Erduran, Ardac & Yakmaci-Guzel, 2006; Ghebru, 2014; Ogunniyi, 2007a, 2007b; Ogunniyi 2004; OrtegaII, AlzateII & Bargallóiii, 2015; Osborne, 2010). Also, Ogunniyi (2007a) identified the use of argumentation as a rhetorical and instructional tool since time immemorial. This is an indication that for decades, argumentation had been widely investigated, proved, and diagnosed by various studies that argumentative practices within the classroom contributes immensely towards enhancing students' understanding of scientific concepts and ability to construct argument (Driver, Newton & Osborne, 2000; Ogunniyi, 2007; Osborne, 2004, 2010; Osborne, Erduran & Simon, 2004, 2006; Venville & Dawson, 2010) development of knowledge and scientific reasoning (Metaxas et al. 2016; Ohlsson, 1992). This probably contributes to Erduran & Jiménez-Aleixandre (2007) strong view about argumentation being an integral part of science that should be imbued into science education, with the understanding that scientific signs of progress were highly driven by argumentation (Erduran, 2006). Therefore, science is embedded in argument because scientists use arguments to establish theories, models, and explanations about the natural world (Erduran, Ardac &Yakmaci-Guzel, 2006).

The understanding of conservation of energy by observation and testing of ideas cannot literally be a process of transmission where knowledge is presented as a non-equivocal and uncontested fact transferred from experts to a novice (Osborne, 2010), describing a one way means of learning that comes from the teacher alone that exists within a traditional teaching approach. Rather, the teaching of conservation of energy as it manifests in our natural world should create an equivocal forum where learners freely contest/express their experience, world views, encounters, taught, and expression about conservation of energy through the use of argumentation tasks.

The involvement of learners in such activities would captivate their interest, eagerness, and understanding, towards other scientific phenomena. Recent evidence proved that argumentation plays a vital role as a fundamental tool for the co-construction of more meaningful understandings of the concepts discussed in class (Diwu, 2010; Erduran, 2008; Erduran & Jiménez-Aleixandre, 2007; Ghebru & Ogunniyi 2016; Ogunniyi, 2007; OrtegaII, et al., 2015; Osborne, 2004).
Teaching methodology had been identified as major contributing factors towards learners' comprehension of certain scientific concepts (Erduran, 2007; February, 2016). In accordance with that Glaze (2018) contended that the use of traditional approaches to teaching science brings about negative perceptions of science and most learners inspiring to become scientists struggles to reach their high level of literacy. In a similar vein, Loughran (2000) describes science teaching as long been characterized with a teaching that is factually based and learning that is appropriate for passing school science tests but has little impact on students' understanding of everyday events.

A vital issue here is that learning is the product of one's intuitive knowledge and the new ideas we come across. Therefore, explicit teaching of science concepts is required to improve learners' understanding and reasoning. Erduran, Simon and Osborne (2004) affirmed that apart from the quality of being logical and consistent with current fundamentals of nature and knowledge of science, there are cognitive values of argumentation in science education. Based on the level of the argument the learners communicate their viewpoint and start reasoning (Iwuanyawu & Ogunniyi, 2019). Hence, Erduran et al. (2004) contend that lessons involving argument for example conservation of energy would engage learners to externalize their thinking. These encompass effectiveness in collaborative learning (George, 2014; Osborne 2010).

Interestingly, Rivard and Straw (2000) acknowledged that discussion combined with writing enhances the retention of science learning for a long time. Therefore, they described analytical writing as an important tool for transforming rudimentary ideas into knowledge that is more coherent and structured.

2.4.3 Collaborative dialogue, reasoning, and writing argument.

The practice of collaborative learning had been embraced by many researchers as an advantageous means of combating prejudices that arise within learners in the conception of scientific knowledge. (Newell & Beach, 2011; Reznitskay et al., 2008). Reznitskay et al. (2008) further consider collaborative reasoning and learning as a progressive means to engage elementary school children in group discussions to curb controversial issues that prompt during learning.

This collaborative learning empowers learners to become good thinkers and it creates room for a better understanding of scientific phenomena (Kuhn, 1992; Reznitskay et al., 2008; Newell & Beach, 2011). As Briker and Bell (2009) reassure that the goal of science education must not only emphasize mastery of scientific concepts but also learning how to engage in scientific discourse and the skills that are needed to partake in it (Kuhn, 2010).

The skills in this study include the learners being able to identify a claim made in a discussion or sentence, counter a claim, and also being able to present his/her claim and defend it by providing evidence through discussion. This study further got embedded with collaborative learning that promotes reasoning, discussions, and writing an argument as well as identification of Toulmin's elements of argument found in a sentence both in individual and group tasks. Amidst this dialogic learning, everyone tends to search for the truth. Searching for the truth prompts reasoning, observation, and reflection on experiences. Ogunniyi (2018) indicates that "science tells the truth about nature and truth itself is a metaphysical term that connotes absolute knowledge" (p.965). Similarly, Bakhtin (1984) affirms that truth is born between people collectively searching for the truth, in the process of their dialogic interaction. Hence, that truth can be simply seen within concrete evidence. It is only when one observes the existence of phenomena and reason about them in line with experience that evidence can be found which makes it a truth.

Therefore, for a truth to be found, "an effective dialogical discussion would be provided where learners can observe, think and try out a variety of argumentative moves, including taking a position on the issue, supporting it with reasons and evidence, challenging the positions of others and responding to counterarguments" (Reznitkaya et al., 2008, p.32). The dialogic interactions appear not only to influence learners learning within the social context but also to help them to internalize communicative mode (i.e., from oral group discussion to a written task performed individually).

- Kuhn (1993) views scientific thinking as a social activity that involves collaborative reasoning.
- The ability to identify the underlying argument and its claims, warrant, and evidence in reading. The ability to compose a high quality argument and its claims, warrants, and evidence in writing are critical skills for academic success (Hillocks, 2010, 2011; Kuhn 2010, 2005; Newell et al., 2011).

2.5 Cognitive constructivism and social constructivism

Cognitive constructivism and Vygotsky (1978) social constructivism takes cognisance of our cognitive and socio-cultural environment during learning. These outlined theories apropos to this study and succours towards the conduct of this research.

Cognitive constructivism and Social constructivism are two learning theories that share similar assumptions when it comes to learning, considering the effectiveness of using argumentation to expand learners' conceptions of the natural phenomena known as conservation of energy. Constructivism was put into context because of its views towards knowledge and learning. Although constructivism is embodied with a combination of multiple theories dispersed into one form, which apprehends both behavioural and cognitive ideas. The main interest of this study lies in how learners construct knowledge during teaching and learning with their already built-in conceptions.

The constructivist had an assumption that the learners' intuitive grasp towards learning new knowledge depends on their previous experience (Brunner, 1990; Piaget, 1972; Vygotsky, 1978). Bearing that in mind, opined that a considerable amount of literature has been published on constructivism Mascolol and Fischer (2005) described constructivism as a philosophical and scientific point where knowledge arises through a process of active construction. The active construction depends on the interactions that take place within the child's environment which they learn from. In a similar vein, Brooks (1999) relates constructivism as a study of learning, and how we all make sense of our world through people asking each other questions, conforms to constructivist classrooms. Jonassen (1991) defines constructivism as a learning theory that assumes that knowledge is actively constructed by the learner.

Similarly, Mvududu and Thiel-Burgess (2012) refer to Constructivism as a way of learning and thinking that probes children's level of understanding and how that understanding can be taken to a higher level of thinking. The constructivists contend that knowledge would be acquired through a continuous gathering of experience, which is developed using an interactive process of construction (Jonassen, 1994; Maria, Machado & Pacheco, 2005; Merrill, 1992).

These imply that constructivism sees human beings "as active agents in their own learning" (Donald, Lazarus & Lolwana, 2010, p.81), with an assumption that all knowledge was constructed from the learner's previous experience from which they construct their understanding of their real world and through teaching, emerge active attempts to construct new knowledge (Jonassen, 1994; McLeod, 2008). The implication is that new knowledge can be constructed only when the teacher knows the learners' pre-existing conceptions and uses it to affect activities that address or declaims their taught and from there build on them. Amineh and Asl (2015) in the agreement stated that "teachers should consider what students know and allow their students to put their knowledge into practice" (p.9). This could be achieved when the teacher acknowledges that learners are not 'empty slate' they already have experience regarding whatever they were being taught. It is so because science content revolves around activities that take place within our environment (RNCS, 2002) e.g., the fundamental law of conservation of energy.

Also, constructivists allege that teachers' dialogue with learners enables them to construct their own knowledge (Lyle, 2008). This draws into inclination towards the use of argumentation to enable the teacher to grasp the learners' pre-existing conceptions of conservation of energy as emphasized by Jonassen (1994). This conforms with DAIM initiation on engaging a discursive classroom environment where teachers and learners argue, dialogue, discuss and learn together with the intention to acquire new knowledge through reaching a consensus (Florence, 2016; George, 2014; Hlazo, 2014; Ogunniyi 2007). As Sampson and Grooms (2009) proposed that "a major goal for science curriculum was for students to develop an understanding of the scientific view of the world and to be able to use scientific reasoning when a situation requires it" (p.66).

Hoover (1996, Discussion section, para. 3) gave a brief account of how learners build new knowledge upon the foundation of previous learning with two notions:

> The first was that learners construct new understandings using what they already know. There is no tabula rasa on which new knowledge is etched. Rather, learners come to learning situations with knowledge gained from previous experience, and that prior knowledge influences what new or modified knowledge they will construct from new learning experiences.
>
> The second notion was learning as active rather than passive. Learners confront their understanding considering what they encounter in the new learning situation. If what learners encounter is inconsistent with their current understanding, their understanding can change to accommodate new experiences. Learners remain active throughout this process: they apply current understandings, note relevant elements in new learning experiences, judge the consistency of prior and emerging knowledge, and based on that judgment, they can modify knowledge.

Hoover also emphasized some important implications for teachers. He argued that teaching should not be viewed as conveyed knowledge from enlightened to unenlightened. Rather, teachers should act as a guide to the learners and provide them with ample opportunities to test the adequacy of their current understandings. The adequacy of their understanding can be explored through argumentation, as Ruiz Ortega, Tamayo Alzate and Márquez-Bargalló (2015) pointed out that argumentation as a dialogic procedure and a fundamental tool is suitable for co-construction of more meaningful understandings of the concepts discussed in class.

These can provide an adequate learning environment that exploits inconsistencies between learners' current understanding and new experiences. Hoover (1996) also contended that, if new knowledge is being built, then time must be allowed to improve on it. The learners reflect on new knowledge, how those experiences line up against current understandings, and how a different understanding might provide students with an improved (not "correct") view of the world (Amineh et al., 2015; Hoover, 1996; Mvududu et al., 2012)

In pursuance of that, Jonassen (1994) contended that "the growth of knowledge evolves through social interactions where multiple perspectives were shared, and our own perspectives change through collaborative learning" (p. 141). This stresses the significance of socialization on individual learning (Kendra, 2017; McLeod, 2007) which takes cognisance of (Vygotsky, 1978) socio-cultural environment.

2.5.1 Social constructivism / collaborative learning

Social constructivism was firmly impacted by Vygotsky's (1978) work. The theory puts more emphasis on instructional and social interaction towards the cognitive development of the child. The learners' mental ability should be considered when it has to deal with the assimilation of knowledge and how the knowledge is conveyed. Vygotsky (1978) contends that social interaction has a lot of positive impact on the child's mental ability as well as intellectual development in the process of learning. Vygotsky (1978) stated that:

> Every function in the child's cultural development appears twice: first, on the social level, and later, on the individual level; first, between people (interpsychological) and then inside the child (intrapsychological). This applies equally to voluntary attention, logical memory, and the formation of concepts. All the higher functions originate as actual relationships between individuals (p. 57).

However, at the social level, it is simply referred to as 'group'. Therefore, in a classroom setting, made up of a group of people, learning cannot be conveyed only from one source such as the talk-and-chalk teaching method where the teacher dominates and do the whole talking. It should involve interaction among a group of people where learners can grasp ideas in a transferable way, conceptualize the knowledge learnt in class, and apply it across other domains.

The social interactions through which the learners learn should stem from guided learning within the zone of proximal development as learners co-construct knowledge (Vygotsky, 1978; McLeod, 2014). Wertsch (1991) explained the zone of proximal development as the range of potential each person has for learning, with that learning being shaped by the social environment in which it takes place. This potential ability is greater than the actual ability of the individual when the learning is facilitated by someone with greater proficiency (Wertsch, 1991). Therefore, teachers as the expertise in the classroom, should be conscious of the use of scientific terms and languages during the process of interaction and guide learners within the range of their intellectual ability.

For instance, as this present study investigates the grade seven learners' conceptions of conservation of energy, the teacher is assumed to investigate this phenomenon within the learners' proximity of the conservation of energy, sources of energy, and how this energy is transformed from one form of energy to another and draw examples from the learners' everyday activities. An old researcher Ausubel (1968) agreed with me that during classroom instruction the teacher is expected to select examples from the learners' everyday lives and by so doing the teacher should ensure that the examples are pertinent to the learners which will inspire their intellectual structure.

However, Lock (1998) draws our attention to a distinctive category that explains thoughts, feelings, emotions, and language as the most important key to the psychological tool. These factors in one way or the other influence our social interaction during learning. Lock further states that Language is the most powerful correct form of communication of knowledge pernitrates from interpsychological to intrapsychological. That means, it incorporates within the learners' thinking and controls their activity.

2.6 Language and understanding of science.

Language had been the key that unlocks and propels a proper understanding of scientific concepts in teaching and learning. Through the medium of language, we transcribe knowledge, learn, discuss, explain, and write science (Webb, 2009). Language had been a medium through which we interact with our environment and make sense of our world (Durrheim, 2011; Ogunniyi &

Taale, 2004). It is well known that through language we communicate, explain, and make clear an in-depth taught that comes within and expresses a point of view.

In science education, a considerable number of literature has been published on the influence of language and its pedagogical role in the understanding of science during classroom teaching and learning in South Africa and beyond (Makalela, 2015; Msimanga, Denley & Gumede, 2017; Ogunniyi & Rollnick, 2015; Probyn, 2006, 2015; Prinsloo, Rogers & Harvey, 2018; Webb, 2009, 2017). The unfamiliarity with the use of the English language, however, result in teaching with the use of traditional teaching methods which erupts into rote learning, reiteration, memorization, and recall (Webb, 2017), which can handicap proper understanding of the concept. These directly deprive learners of the ability to think or reflect critically over what they have been taught. MacDonald and Burroughs (1991) contend that teaching a child in a foreign language would limit the child's knowledge of the language, hence using the first language increases the learners' level of thinking and thinking skills.

Research had shown different means at which the use of language could be used during classroom learning such as the role of home language, bilingualism, code-switching, mobilizing home language, and multilingual dictionaries in classroom scientific interactions (Clerk & Rutherford, 2000; Cummins, 2000; Msimanga, et al., 2017; Setati, 2007). However, these expatriates the significant role language impacts in understanding science and its concepts. Referring to Burner's (1978) study he contends that "Language is important for the increased ability to deal with abstract concepts. He further argued that language can code stimuli and free an individual from the constraints of dealing only with appearances, but to provide a more complex yet flexible cognition" (p. 33).

Similarly, Ogunniyi and Hewson (2008) construe on how the integration of indigenous knowledge that emanates through language can propel ideas and reasoning towards the understanding of scientific phenomena. Contrarily, Bruna, Vann and Escudero (2007) contend that scientific language developed not just as a tool for expressing scientific meaning, it also played an important role in construing the possibility for such meaning. Research studies aligned the problem to be associated with the use of English as a medium of teaching (Prinsloo, Rogers & Harvey, 2018;

Msimanga et al., 2017; Ogunniyi & Rollnick, 2015) as well as the academic language of science (Snow, 2010). Zwiers (2008) defines academic language as a “set of words, grammar, and organizational strategies used to describe complex ideas, higher-order thinking processes, and abstract concepts” (p. 20). However, Msimanga et al. (2017) affirmed language to be one of the causes of persistent differential achievement in science among South African learners.

The fact being that the content of every scientific concept was conveyed through language (Lemke 1990; National Research Council [NRC], 2014; Osborne & Wellington, 2001). For learners to achieve academic success in science, “they need to practice those language skills that allow them to back up claims with evidence, be more detailed in their observations, use persuasive language compellingly in arguments, and compare events or points of view” (Zwiers, 2008, p. 20). Therefore, the use of learners’ first language to communicate meaning into scientific concepts could be very important as (Langenhoven, 2005; Leach & Scott, 2000; Nomlomo, 2014; Oyoo, 2015; Prinslo, 2011) contend that learner’s home language facilitates learners’ construction of meaningful knowledge. Leach and Scott (2000) also contend that the learners’ home language is a measure upon which new learning experiences are built.

More than one language would be involved for a proper understanding of scientific concepts viz, the learners’ first language, approved language of teaching (English), and science academic language’. According to Cummins (2000) during the course of learning one language, a child acquires a set of skills and implicit metalinguistics knowledge in the course of his/her first language and that can be drawn upon when working in another language, e.g. academic language. That means that the use of learners’ first language has a beneficial effect on other languages.

Several reasons have shown the need to use learner’s first language in teaching science, but the emergence of multicultural learners in our present classrooms in South African schools and beyond posed a great challenge in the educational system (Ogunniyi, 2016) to both teachers and second language learners. This point towards the difficulties in the conceptual grasping of scientific concept during teaching and learning. As we know that when one’s language is deprived of an individual, the person is left empty. To alleviate this emanating problem, Ogunniyi (2007) introduced DAIM as a teaching tool that could enhance scientific teaching through the argumentation process. Heitmann, Hecht, Schwanewedel and Schipolowski (2014) study affirmed that argumentation helps to shed light on learners' use of the first language and reasoning abilities on the domain specificity of argumentation in science.

One study by Swanson, Bianchini and Lee (2014) indicated that science instruction must present language as a mediator of the teaching and learning process. Osborne et al. (2001) emphasized that language does not matter in science but what matters is what we do with the language. This proposes the relevance of the language towards understanding a concept and in as much as to avoid using language to bring in meanings that might contradict the scientific phenomena for example in teaching conservation of energy.

It happens that most times language choice sharpens what kind of science learning takes place (Bruna, Vann & Escudero, 2007). The use of similarities in languages to convey meaning in scientific concepts (e.g. Conservation of energy) most times bring about different misconceptions about the phenomenon. Therefore, the above explanations bring consciousness to the researcher towards the technicality of using science language during teaching, as this study explores whether the learners' conceptions of conservation of energy were related to their language.

2.7 Theoretical Framework

This research is framed within the Dialogical Argumentation Instructional Model (DAIM) which is rooted in two argumentation framework known as Toulmin's (1958, 2003) Argumentation Pattern (TAP) and Ogunniyi (1997) Contiguity Argumentation Theory (CAT).

2.7.1 Toulmin's Argumentation Pattern (TAP)

Toulmin (1958) Argumentation Pattern (TAP) had been the bone of contention that constitutes the essential supporting structure of this study. Numerous studies have proved TAP's methodological tool as an advantageous pedagogic practice not only used for enhancing proper conceptions of scientific concepts, a tool for assessing a small and large group of student discussions and logical argumentation but helps in argumentative analysis of both quantitative and qualitative discussions of teaching and learning that transpires in the classroom (e.g. Erduran, Simon & Osborne, 2004;

Ghebru, 2014; Hlazo, 2014; Jimenez-Aleixandre, Rodrıguez & Duschl, 2000; Ogunniyi, 2007; Simon 2005).

Toulmin drew his inspiration from Aristotelian deduction and induction logic. The deduction points to the valid statement or conclusive truth with evidence of what the premises claimed to provide in any argument while the inductive establishes the truth of the conclusion as probable or probably true (Mankato, Bruno & Company, 1992). Toulmin structured some prerequisite elements to use for proper understanding and making of arguments. Thus, he breaks the argument down into different essential parts. The three major necessary parts (Claim, Data, and Warrant) and three ancillary parts though optional (Qualifier, Backing, and Rebuttal), but all were interconnected and depend on each other to form a complete argument.

The elements are as follows (Toulmin, 1978, p.11)

- Claim: Toulmin states that "a claim is an assertion put forward publicly for general acceptance. A man who makes an assertion puts forward a claim—a claim on our attention and to our belief. In whatever the nature of the assertion might be, one can challenge the assertion, and demand to have our attention drawn to the grounds (backing, data, facts, evidence, considerations, features) on which the merits of the assertion are to depend". These he ascertains can prompt an argument provided it is supportive prove were of standard. Hence the primary function of any argument lies in the grading, assessing, and criticism placed on the claim.

- Data: It entails the information on which our claim based or facts we appeal to as a foundation for the claim. That means the specific facts relied on to support a given claim or rationale for the claim. Data entitles one to conclude, but for more explicit propositions Toulmin established a warrant.

- Warrant: It is the most important contribution of Toulmin's scheme to one's conceptions of argumentation. The warrant distinguishes the conclusion from data and hence draws a connection between the claim and data. It identifies assumptions that people are unable to share (often unspoken) during an argument.

- Backings are "generalizations making explicit the body of experience relied on to establish the trustworthiness of the ways of arguing applied in any particular case." It provides support for the warrant.

- Rebuttals are "the extraordinary or exceptional circumstances that might undermine the force of the supporting arguments." It is a potential objection to our claims and makes our argument more nuances and complete as it makes one conscious of the oppositions to our perspective.

- Qualifier: Limits put on the claim.

The claim, data, and warrant were the primary components of the model while the Backing, rebuttal, and qualifier were the secondary components because they supplement the primary components.

The Toulmin Schematic

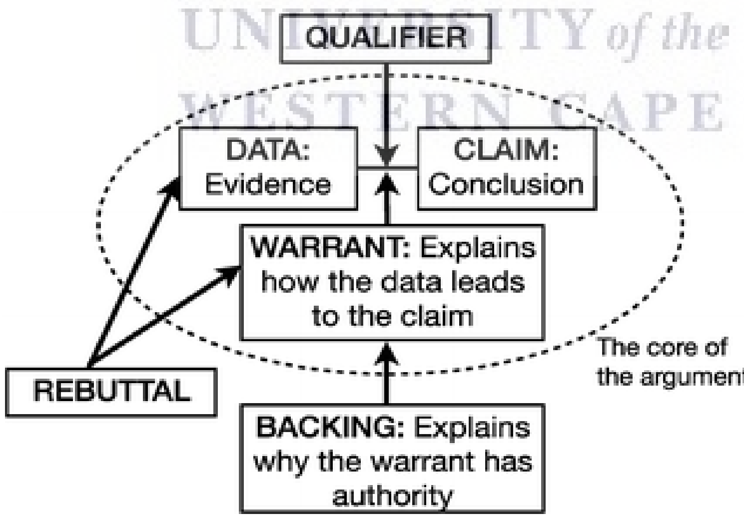


Figure 2.2. Toulmin's Argument Pattern (Toulmin, 1958,2003).

The above diagram (Figure 2.2) illustrates the steps within the statement and all the components play a unique role that unfolds within the argumentative discussion. Toulmin further used a practical example to illustrate how these elements were interconnected during the process of argument. Yackel (2001) affirms that "what constitutes the elements i.e., data, warrant and backing is not predetermined but is negotiated by the participants as they interact" (p. 7). See the illustration below (Figure 2.3).

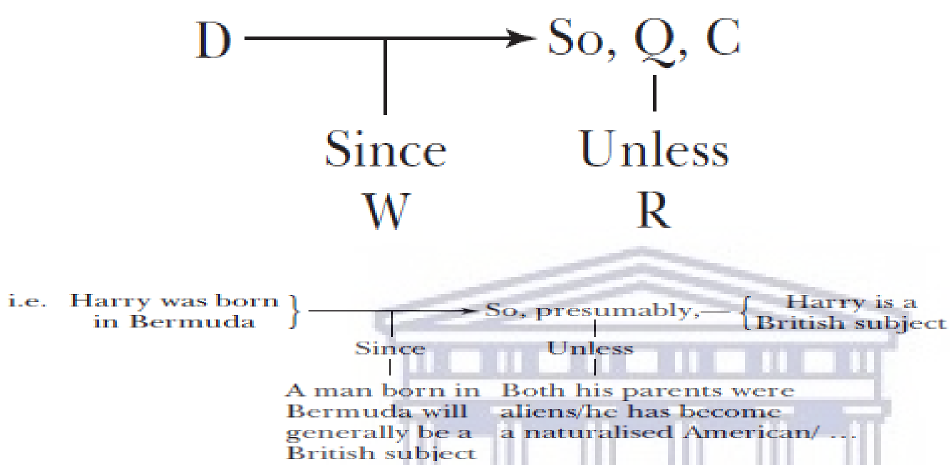


Figure 2.3. Toulmin's (2003) Argumentation Pattern of illustration.

The above illustration can be expressed using the law of conservation of energy to illustrate an argument that happens among learners including individuals during the cause of learning. This study also used the above illustration to express the argumentative pattern that happens within an individual or among learners during the teaching and learning of conservation of energy as it patterns our daily experience. See the illustration below (Fig. 2.4).

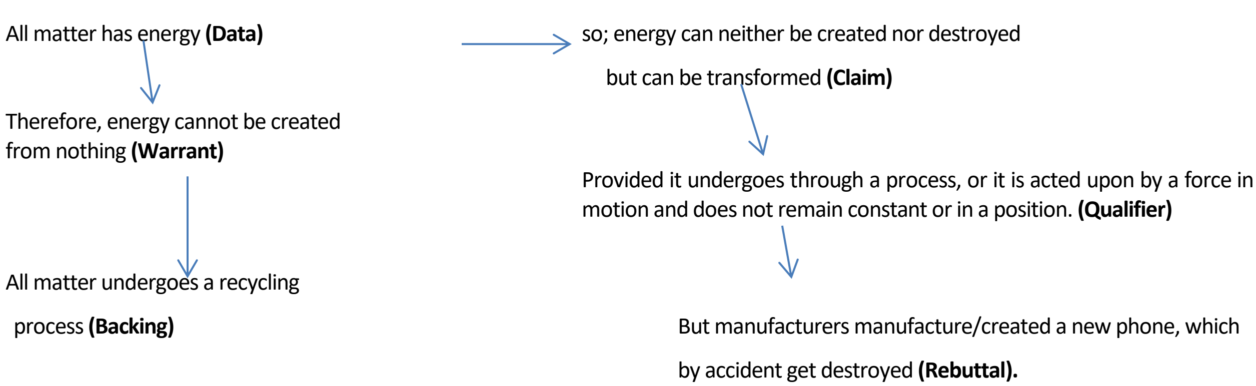


Figure 2.4. Conservation of energy in daily experience pattern.

The rebuttal simply draws attention towards this study, as the learners tend to ask the question; energy can neither be created when new things are created every day by manufacturers and producers, hence old things also get destroyed and where does the energy go to after being used up?

Table 2.1: Analytical Framework Used for Assessing the Quality of Argumentation (Erduran et al., 2004, p. 928)

Level 1	Argumentation consists of arguments that are simple claim versus a counter-claim or a claim versus a claim.
Level 2	Argumentation has arguments consisting of a claim versus a claim with either data, warrants, or backings but does not contain any rebuttals.
Level 3	Argumentation has arguments with a series of claims or counter-claims with either data, warrants, or backings with the occasional weak rebuttal
Level 4	Argumentation shows arguments with a claim and identifiable rebuttal. Such an argument may have several claims and counter-claims.
Level 5	Argumentation displays an extended argument with more than one rebuttal.

In the table above (Table 2.1), the Level 1 argument is indicated as the most effective, typically comprising a claim or an unjustified counter-claim in reaction to the claim under discussion. It is taken into consideration as the lowest level of experience expected in an argument in that it shows beginners (e.g., young learners) the bottom level of argumentation skills. However, stage five happened to be the maximum complex kind comprising all Toulmin's prerequisites for an argument and extended argument with a couple of rebuttals.

Focusing on the content of the analytical framework used for assessing the quality of argumentation, Erduran, Simon and Osborne (2004) modified the TAP's levels and classified them into seven levels of argumentation in order to determine the degree of an argumentation process. The levels progress from level zero to level six as shown in the table below (Table 2.2).

Table 2.2: Levels of argumentation

Quality	Characteristics of an argumentation discourse
Level 0	Non-oppositional
Level 1	An argument with a single claim with no grounds/evidence or rebuttals.
Level 2	An argument with claims or counterclaims with grounds /evidence but no rebuttals.
Level 3	An argument with claims or counterclaims with grounds /evidence but only a single rebuttal challenging the claim
Level 4	An argument with multiple rebuttals challenging the claim but no rebuttals challenging the grounds (data, warrants, and backings) supporting the claim.
Level 5	Arguments with multiple rebuttals and at least one rebuttal challenging the grounds.
Level 6	An argument with multiple rebuttals challenging the claims or counter claims and respective grounds.

To this effect, the researcher investigated possible shortcomings encountered by other researchers after reading through the levels of the argument. Then explored by other arguments that erupt within a learner's mind when dealing with conflicting scientific concepts as elaborated by CAT.

2.7.1.1 Criticism of Toulmin's model

Despite the advantageous use of TAP's Model to enhance science teaching and learning, as well as analysis and evaluation of practical arguments, some researchers still found its downside. Nussbaum (2011) affirmed and outlined different purposes expected in a specific argumentation model. There are as follows: One purpose was analytical, the second purpose; normative, and the third purpose; descriptive. However, Toulmin's model was limited to those outlined purposes, with the notion that the model was not descriptive in social and psychological practices.

Secondly, Toulmin's model was not primarily normative because he asserts that all arguments have six components. Toulmin's model does not provide a basis for judging argumentative strength. The Toulmin model was somewhat limited as an analytic tool as Erduran (2008, as cited in Nussbaum, 2011) argued that many researchers found it difficult to reliably distinguish certain categories, such as warrants and backing.

Another researcher Kim and Roth (2014) emphasized the irregularity and difficulties noticed in analysing children's argumentation with the TAP framework and coding learners' discourse (Nielsen, 2013; Nussbaum, 2011; Roberts & Gott, 2010). Also, Kim et al. (2014) piece of work expressed TAP's limitation in the aspect of social relations (Erduran, 2018).

2.7.1.2 The implementation of TAP to the study

TAP was applied in this study to evaluate the quality of argumentative discourse originated from classroom discussions during science lessons (Erduran, 2004). This was assessed through the learners' ability to apply any of the first three TAP levels of argumentation in their dialogue. These 1st three levels were in consideration to their argumentative skills as young learners. Furthermore, to use Toulmin's levels of argumentation to determine the learners logical reasoning, and to analyse the extent to which the learners' understand and make use of Toulmin's elements of argumentation namely; data, claims, warrants, backings, qualifiers, and rebuttals (Simon, Erduran & Osborne, 2006; Erduran et al., 2004).

However, Erduran (2018) comparative study reported that "TAP is not inherently incapable of addressing social relational aspects of argumentation in science education but rather that science education researchers can transform theoretical tools such as Toulmin's framework intended for other purposes, for use in science education research" (pp.1-8). Moreover, the aspect of the social relations of argumentation remains relatively under the specified territory of research. This was where the Contiguity argumentation theory emerges to bridge the gap of TAP limitations.

2.7.2. Contiguity Argumentation Theory (Ogunniyi 2007a, b)

CAT was informed by both Aristotelian and Ubuntu, a central African worldview theory. The theory construes both logical and non-logical interpretation of phenomena (Ogunniyi, 2007a), that TAP could not cover because it explains both empirically testable facts and non-direct testable facts. As a bridged principle (Ogunniyi, 2007) CAT insightfully, dealt with the nature of interactions between distinct different thought systems which inductive, deductive, and practical reasoning could not put into consideration.

However, the theory described a dialogical framework for solving the incompatibilities that most times arise when two or more competing thought systems e.g., Science, Indigenous Knowledge System (IKS), cultural beliefs, common-sense or intuitive notions emerge in a learning situation. Ogunniyi, (2007b) further, indicated that such thought tends to create cognitive conflicts among learners.

Furthermore, CAT assured that a kind of internal argument or conversation erupts within the learners' mind at a point and described that point of self-taught as a micro-neuro-psychical level, which can be metamorphous to another stage known as the macro-level where other people are involved in the same argument or conversation. At this stage, CAT elaborates some cognitive-intuitive conceptions that happen within a learner's mind when dealing with conflicting scientific concepts with everyday experience. CAT discussed five categories of notions contrary to common sense expectation that exists within the learner's mind as follows:

- Dominant: This exists when one's strong belief or idea tends to subdue other thought systems and thereby create a sort of rival in between them.
- Suppressed: a point when valid, predictive, empirically testable evidence, or established social norms overlap and subdue the existing taught or dominant belief.
- Assimilated: when a weak idea suddenly empowers a stronger one due to the persuasiveness or adaptability of the dominant idea to a given context
- Emergent: a situation when a new idea is acquired because there was no related previous existing idea in mind.
- Equipollent: when two rival ideas tend to co-exist without any existing conflict.

These categories of thought tend to manifest congruently within an individual on the verge of dialogue, discussion, or conversations.

2.7.2.1 The implementation of CAT to the study

CAT was chosen because of its capacity to deal with both logical and non-logical but culturally valid arguments in a discourse. As mentioned earlier, to analyse motives that do not simply fall under deductive (logical) reasoning on which TAP was based (Ogunniyi, 2007). CAT was used to distinguish the quality of argumentation discourses originated during the intervention process, among grade seven learners, and in their argumentation task test. Furthermore, to explain the kind of conceptions and perceptual differences, and changes that might have reinforced as a result of learners' exposure to DAIM.

The central concern of this study has been to determine the effects of the DAIM on Grade seven learners' conceptions of conservation of energy as typified in science and everyday knowledge. The argument here is that the infusion of two distinct worldviews using DAIM as a method of instruction in a science classroom tends to trigger off cognitive conflicts in the learners' minds (Diwu 2005). The application of TAP and CAT is found in this study as in earlier studies emerge to be effective for resolving conflicts that arise between learners' prior ideas and what is taught in school science in this case, the conservation of energy.

2. 8. Summary

This chapter reviewed the conceptual framework and ideas from related studies, including substantive findings as well as theoretical and methodological contributions to this study. Firstly, it drew attention to how the description of the concept 'energy' contributes to an alternative understanding of the conservation of energy. The alternative conception was discussed and invariably instigated from various definitions and ideas generated from different disciplines in conjunction with learners' experiences, worldviews, and belief systems. However, empirical studies were presented to that effect and how learners' alternative conceptions could be circumvented. Hence, thought system in the context of learners' worldview was presented with the need for teachers to clarify their thoughts on any scientific concept.

Furthermore, interrogative literature on the role of language, age, and gender was reviewed, to find out its possible effect on learners' conceptions of conservation of energy. Hence, the detailed review of the innovative teaching approach known as Dialogical Argumentation Instructional Model (DAIM), rooted on two argumentation framework known as Toulmin's (1958, 2003) Argumentation Pattern (TAP) and Ogunniyi (1997a, b) Contiguity Argumentation Theory (CAT) were reviewed with other vital background information. The concept of DAIM as a platform where learners are exposed to argumentation and how they are used to resolve disagreement and controversies in scientific concepts within a classroom setting was discussed. Also, different elements of DAIM were highlighted and the importance of collaborative learning in the aspect of assimilation of knowledge was clearly expressed as it contributes to the methodological proceedings in this study.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

The previous chapter reviewed the relevant extant literature related to learners' conceptions of abstract ideas such as the conservation of energy. This puts the study into a proper perspective. It described both the theoretical and empirical perspectives that have a significant bearing on the central concern of the study i.e., "learners' conceptions of conservation of energy."

This chapter, therefore, describes the procedure undertaken to explore the purpose of the study and tackles the research questions in due course. It however displays a high intellectual human activity that investigates and deals specifically with the manner in which data were collected, analysed, and interpreted (Creswell, 2012; Patton, 2002). These were elucidated through a sample, research design, developed instruments, research procedure, data collection techniques, and analysis procedures. Also, a detailed account of the validity and reliability of the instruments was provided in this chapter. Research ethics and the implication of the study were included.

3.2 Methods

The study adopted a mixed method approach which constitutes both quantitative and qualitative research methods. A considerable number of studies has shown that the mixed methods approach acts as a powerful tool when investigating complex issues relating to learners' conceptions of different scientific phenomena (Creswell, 2012; Creswell & Clark, 2017; Fetters, Curry & Creswell, 2013; McKim, 2017). Patton (2002) asserts that the integration of quantitative and qualitative methods can be used in a single research project depending on the kind of study and its methodological foundation. Hence, the most important assumption of the mixed approach is that it creates an absolute understanding of the research problem (i.e., learners' conceptions of conservation of energy) which each of the approaches alone could not do (Creswell, 2014). This adds value to the findings (McKim, 2017).

Collis and Hussey (2003) argue that the advantage offers a thorough description and analysis of a research subject, without limiting the nature of the participant's response within the scope of the research. Significantly, the quantitative approach involves numerical comparison among participants' conceptions on the conservation of energy through a pre and post-test. Qualitative research became suitable for a small sampling and descriptive since its outcome often cannot be measurable and quantified. In accordance with that, the adopted designs were strategies associated with quantitative designs (quasi-experiment) and the worldviews (interpretivism) as an approach to qualitative research.

The mixed research approach was situated within an interpretive paradigm that was utilized for data collection. The interpretive views and positions were embedded largely in this present research with reference to the already discussed theoretical frameworks explained in chapter two such as Constructivist/Social-constructivist, Contiguity Argumentation Theory (CAT), and Toulmin's Argumentative Pattern (TAP). The interpretive paradigm was concerned about understanding the world as it is, from the subjective experience of individuals (Thomas, 2010) and the nature of knowing the reality which could be referred to as truth.

The key idea here had been that we cannot separate ourselves from the realities, experiences, and knowledge gathered within our environment. Therefore, conceptions about conservation of energy in this study explored a whole lot of information based on grade seven learner's level of observation, experience, and the actual realities as stated by the law of conservation of energy. The interpretivists accepted the knowledge of reality to be socially constructed (Willis, 2007) by a number of persons through the explanations they present, the understanding developed personally, socially, and experientially where the finding of truth, evidence, and claims migrates through dialogue.

Furthermore, the adoption of mixed method approach in this study creates room to investigate the learners and to understand a given research problem from different perspectives such as written work, discussions, dialogues, verbal communication, body language, non-verbal expression, etc. by triangulation and through the converge of the result (Creswell, 1999). These activities were conveyed during intervention with the use of questionnaires, science achievement tests, argumentation tasks, observation during the intervention, and a group interview.

However, the mixed method created room to unearth the underlying reasons why and how energy cannot be created or destroyed… as learners might think, that 'we create energy and destroy energy in different ways. It thus enabled us to gain a holistic picture of the phenomenon (Yin, 2009). The mixed method approach also provided an avenue to ask more complex questions with complex answers (Gelo, Braakman & Benetka, 2008) as well as address more diverse views and concurrently respond to exploratory and confirmatory questions (Schulenber, 2007; Wiśniewska, 2011).

As stated earlier, I used a mixed method approach to collect data. It is hoped that the use of more than one approach to explore grade seven learners in two schools in Cape Town enhanced the validity and reliability of the study. Cohen, Mansion and Morrison (2007) contend that "Both qualitative and quantitative methods can address internal and external validity" (p. 135). However, the use of more than one method provided different sets of data through triangulation and in turn ensured the reliability and validity of the research outcomes.

3.3 Research Design

Research design is a plan of what data to gather, from whom, how, when to collect the data and how to analyse the data obtained (Creswell, 2012). Welman, Kruger and Mitchell (2005) contend that it is a plan of research used to answer the research objectives, the structure, or framework to solve a specific problem.

I employed a Quasi-experimental (Non-equivalent groups) design, to examine Grade 7 learners' conceptions of conservation of energy (henceforth, CCE) in a Dialogical Argumentation Instruction-based classroom. The research design was carefully selected among many other types of research designs because of the nature of my study. The non-equivalent group design was structured to assess pre-and post-test measures of the study in which two groups were selected from two schools assumed to be similar in terms of age, educational background, geographical setting, language, and average and above average learners.

A quasi-experimental design is utilitarian in identifying general trends from the results, and where the groups are similar, matching procedures were applied to help create a reasonable control group by making generalizations more feasible (Creswell, 2012; Ogunniyi, 2003). Most importantly, where there is a variation in experimental research, the validity of the design was still maintained.

However, Bradley (2018) contends that pre-existing factors and other influences are not considered because variables are less controlled in quasi-experimental research hence, research must adhere to ethical standards to be valid. The adoption of a quasi-experimental design was planned to expose a group of grade seven learners to a type of treatment using DAIM that was hoped to enhance their CCE while a certain group was controlled. This measure was known as the pre-test-post-test control group design (Ogunniyi, 2003).

In consideration, two groups of grade seven learners from two different but comparable township schools were used. One school was used as an experimental group and the other as a control group. The experimental group was exposed to DAIM during the intervention and the control group was not rather, they were taught using normal traditional classroom teaching methods.

The two groups (Experimental group and Control group) were conveniently selected based on their similarities, equivalent to different factors and levels of understanding (Ogunniyi, 2003). Hence, a quasi-experimental design measured the differences between the experimental and control group's CCE (Punch, 2009; Campbell & Stanley, 2015). The exercise was prepared according to the procedure used by Ogunniyi (2003, p.88) as follows:

Pre − test		**Post − test**	
O1	**X**	**O2**	(**Experimental group, E**)
O3		**O4**	(**Control group, C**)

The symbol 'O' depicts phases of observations. Where O1 and O2 represent the experimental group administered with pre-test, post-test, before and after the intervention. Then, O3 and O4 represent the control group, and they were also administered with pre-test and post-test but were not exposed to any form of treatment rather they were taught using the traditional method approach. X represents an experimental variable known as the Dialogical Argumentation Instructional Model (an intervention strategy) of which the effect was measured.
However, both experimental and Controlled groups attempted the pre-test, and post-test, (before and after the learners had been exposed to DAIM and Traditional method) with the same instruments which include; Science Achievement Test (SAT), Idea about Conservation of Energy Questionnaire (ICEQ), Cloze Test, Observation and Attitude to science test.

These instruments were used for the study, but most times, the variables being measured were subjected to change over a short period. Therefore, one way to obtain a reliable result using this type of design is by making numerous pre-test and post-test measurements with different instruments (Ogunniyi, 1995).

Hence, the learners' CCE was investigated, the outcome of interest was measured and interpreted. Above all, the result from different instruments yielded an outcome in relation to the treatment (Campbell & Stanley, 2015; Trochim, 2006), as well as influence on their age, language, and gender based on their conceptions.

Therefore, the study was grounded on a quasi-experimental (non-equivalent) design as it investigated a change in teaching method (intervention) which produced more effective teaching outcomes (Mouton, 2006).

3.4 Sample

Welman et al. (2005) defined sampling as a set of cases drawn from a population. Therefore, this study was conducted in two schools located in Cape Town, in the Western Cape Province of South Africa. The schools were listed under the Metro-North district of the Western Cape Education Department (WCED). They were known as township schools, situated in the same geographical area with a distance of 5km apart. The area in which the study was conducted can be classified as a semi-urban or township and is only occupied by the Black communities, mostly of the Xhosa ethnic group residing mostly in the Reconstruction and Development Programme (RDP) houses and few shack houses. The parents and guardians of those learners were from a wide range of socio-economic backgrounds: the middle class, domestic workers, professionals, and unemployed.

The two schools usually commenced classes at about 7h00am and closed at 12h30 pm from Monday to Friday except on public holidays. This short learning time frame was as a result of insufficient school buildings within the area. The learning infrastructures were shared by two schools at different hours: secondary and primary schools. The primary schools functioned in the morning and dismissed at noon while the secondary school commenced teaching and learning in the afternoon and dismissed in the evening. A spare classroom was allocated for my study as the selected learners stay behind after their school hours for the study. Other mitigating measures were put in place to ensure that the students stayed focused and active during the study. Learners used for this study were grade seven learners selected from the two primary schools. The English language was used as the medium of instruction. Average learners and above average learners were selected for the study and the learners were all black.

The two schools were taught twice a week on different days (Monday – Thursday). As a result of the learners' limited school hours, the study commenced at the same time 1h00pm and ended at 2h00pm (1hr) each day. This time was strictly mapped out for the research by the school administration to avoid any obstruction in the schools' learning timetable. Learners attended their normal classes with their teachers on a different content and afterward attended my research class on conservation of energy with E-group being exposed to DAIM and C-group being exposed to TIM. I taught the two groups without allowing or advantaging one over the other. In other words, neither group was given any special treatment. Besides, I was not a regular teacher in any of the two schools and since I could not predict which group would perform better than the other I tried as much as possible to maintain ethical standards and fairness. In addition, I sought the service of an experienced science educator with a doctoral degree to serve as an independent observer throughout the study period. The observation was carried out based on the research design (quasi-experimental design). The implementation of the new instructional model and practices were observed. Most importantly learners' participation in group discussions and their consistency in the use of different levels of argumentation in their discussions were observed and recorded. The recorded observation was used to determine what progress and development the learners had over the intervention period.

It is worthy of note that, adhering to the ethical considerations during the course of the study, the schools were fictitiously called Metro Primary school and North Primary school.

3.4.1 The Experimental group

North Primary School was chosen as the experimental group. It was a government owned primary school. The school started in 2004 with a total number of 1430 registered learners (grades 1 – 7) and 38 teachers at the time of the study. The school had two security men, three cleaners, and cooks. North Primary school had well-equipped infrastructures with spacious classrooms, library and sports facilities, etc. However, the school had three classrooms for grade seven learners, with an average number of 35 learners per class. Grade seven learners were taught Natural Science by three (3) teachers.

At the commencement of the study, a total of forty (40) learners were selected to participate in this study. This number of learners were selected based on the school principal's initiative and decision. Her considerations were based on:

- The number of learners who were willing to stay back after school.
- Learners' academic records: this was used as the number one criterion.
- The difficulty as a researcher to control the entire learners alone after school.

Finally, average and above-average learners were selected by the Head of Science Department (HOD) and natural science teachers as instructed by the principal. This group of learners were taught on Tuesdays and Thursdays from 13h00pm till 14h00pm (1hr) respectively. They all participated at the beginning of the study and they all wrote the pre-test.

However, only 24 learners wrote the post-test because it clashed with the provincial music competition in which many were participants. In view of ethical consideration, learners' participation was voluntary, so they were free to withdraw if they felt uncomfortable or found it inconvenient to participate at any stage of the research process. This gave room for some of them to withdraw from the study since it clashed with their time for leisure and sports. However, I kept on encouraging them and went further to enlighten them on how important and beneficial the study would be to them in their present and future studies in science. In the end, 24 learners in the experimental group participated in the study. They wrote the pre-and post-tests and the 24 scripts were analysed.

Table 3.1 below shows the learners' distribution according to sex and age. The majority of the learners are females between the age of 12 and 13 years.

Table 3.1: Sample Distribution in Terms of Gender and Age for the Experimental Group

Gender/Age	11 years	12years	13 years	14 years	Total
Male	-	2	4	1	7
Female	1	7	7	2	17
Total	**1**	**9**	**11**	**3**	**24**

3.4.2 The Control group

Metro Primary School was used as the control group. The school was also a government owned school. The school started in the year 2004. They had a population of 1300 learners (grade 1-7) and a total of 37 teachers. Grade seven had five teachers and three (3) of them teach Natural science. One of the teachers obtained a Degree in Life Science with a Post Graduate Certificate in Education (PGCE) and the other two teachers obtained the same qualification in Bachelor of Education (B.Ed.).

To be in the same range as the other group, I requested the principal of the school to give me the caliber of learners I needed for the study. Hence, a total of 41 learners were selected from 160 grade seven learners from the school. The selection was carried out by the Head of Science Department (HOD) and the teachers. Average and above-average learners were selected. These selected learners made up a class, they were taught on Mondays and Wednesdays from 13h00pm till 14h00pm (1hr) respectively. The learners co-operated throughout the six weeks of teaching. During the post-test, 39 learners participated and wrote the tests. Two learners were absent from the school on the day of the post-test due to ill-health. See the table below (Table 3.2). The table shows the sample distribution in terms of gender and age.

Table 3.2: Sample Distribution in Terms of Gender and Age for the Control Group

Gender/Age	11 years	12years	13 years	14 years	Total
Male	-	2	11	1	14
Female	1	6	16	2	25
Total	**1**	**8**	**27**	**3**	**39**

The control group was taught through the normal traditional teacher dominated instruction. This had a relatively similar distribution to the experimental group with more girls than the boys and most of them congregate around 12 and 13 years of age. Overall, the two subsamples consisted of 63 grade seven learners, which is 24 learners from the experimental group and 39 for the control group. To reduce the disparity between the two groups, I reduced the control group to 24 through a randomization procedure.

As indicated above in table 3.1 and 3.2, showed that there were more girls in class than boys, as a result, I used a stratified random sampling approach; in the ratio of 2:1 i.e. for every two females, one male was selected. Randomization laid down the ground rule. Therefore, the two groups were rounded up to 24 participants each and a total of 48 participants were selected for analysis.

3.5 Research Instruments

The research instruments are those materials used to source data in this study. Various instruments were developed to elicit learners' conceptions of conservation of energy. The instruments include The Science Achievement Test (SAT), Cloze Test (CT), Idea about Conservation of Energy Questionnaire (ICEQ), Individual Attitude towards Science Questionnaire (IASQ), Classroom Observation, and Interview. Commenting on the numerous instruments, Zohrabi (2013) argued that obtaining information through different sources can augment the validity and reliability of the data as well as heighten the dependability and trustworthiness of the data and their interpretation.

3.5.1 Validity and reliability of the instruments

The validity of the instruments measured the conceptions of conservation of energy among grade seven learners. Thus, the instruments were developed from various concepts of conservation of energy spread across six weeks of instructions. These instruments were subjected to the scrutiny of six experts in the field of science education to ensure the reliability and validity of the instruments for credible results. The expert's comments were carefully studied, and necessary revisions were made before the instruments were administered to explore the learners' pre-and-post conceptions of conservation of energy.

Furthermore, the reliability of the instruments was assessed. According to a definition provided by Leedy and Ormrod (2010, p. 29) "reliability is the consistency with which a measuring instrument yields certain results when the entity being measured has not changed". Also, Ogunniyi (2003) pointed out that the suitability or accuracy of the data collected from a given test is reliable, only if it produces identical results when repeated two or more times under similar situations. To determine the reliability of a test or instrument, Ellis and Levy (2009) noted that reliability could be assessed through different statistical procedures.

In that case, this study applied two measures to achieve the reliability of the instruments. Firstly, the equivalence was assessed with inter-rater reliability and secondly, its internal consistency was measured. The Inter-rater reliability focused on the coefficient of agreement across the results of two or more ratters that completed the same measurement instrument (Haradhan, 2017). Therefore, the level of consistency across the scores obtained from the six experts from the field of science education (judges) was statistically assessed with inter-rater reliability, and 0.97 was obtained which indicated strong reliability. Also, Cronbach's alpha test was used to determine the internal consistency among the items in Science Achievement Test, 0.91 was obtained which showed adequate reliability.

3.6 Data collection

The data as earlier indicated were collected using both qualitative and quantitative approaches. The method sets the boundary for the study such that qualitative data builds directly on the quantitative results (Cresswell, 2014). The instruments were constructed to determine learners' understanding of the conservation of energy. It was administered in the harmonization of an instructional strategy. The learners' responses provided the primary data sources that answered the research questions. These were carried out before (Pre-test) and after (Post-test) the intervention. The section below gave a detailed presentation of each of the research instruments used in this study.

3.6.1 Science Achievement Test (SAT)

Shavelson and Ruiz-Primo (1998) described the SAT as a measuring instrument that taps different characteristics of a subject content that constitutes the important facts about a concept within the critical research domain. The SAT includes some forms of knowledge that probe within the learners' conceptions on the conservation of energy.

Therefore, the nature of the instrument compelled the researcher to draw some context from Bloom Taxonomy's educational objectives, and the learners thinking skills and possible conceptions were considered. The Science Achievement Test (SAT) was designed to measure the amount of general knowledge and conceptions learners accrued in the area of conservation of energy.

The questions were made up of two sections. Section A comprised of the biological characteristics of the learners and Section B investigates their knowledge, understanding, their comprehension, application, and evaluation of the concept within a real-life situation.

The content of the instrument in Section B was derived from the Natural Science curriculum as well as other relevant textbooks. Specifically, from term three, week 2 to week 4 work of grade seven learners' syllabuses in the Natural Science curriculum. Strand: Energy and Change sections of the Curriculum Assessment Policies (CAPS) document. It includes the following content (Department of Basic Education, 2011, p.26):

- ***Sources of energy***
  - Renewable and Non-renewable sources of energy
- ***Forms of Energy***
- ***Potential and Kinetic Energy***
  - The potential and kinetic energy in a system
  - Law of conservation of energy (Department of Basic Education, 2011, p.26).

The synthesis of the science achievement test was carried out according to the procedure of Ogunniyi (1992). He argued that the science achievement test measures what the learners were aware of or already known and had achieved after a learning experience. Hence, the structured questions were drawn from the aforementioned with a focus on the law of conservation of energy, to explore their conceptions. This instrument was used in its original form to study the underlying conditions and conceptions that affect learners' from grasping the knowledge of the law of conservation of energy during learning.

Furthermore, a picture test was included in the achievement test to establish the degree of conceptions that the learners hold in the identification of certain scientific diagrams and pictures. The Pictures had descriptions of energy transfer and conservation to identify and state their thought about the pictures. One of the questions requested learners to draw imagery of energy transformed from one form to another etc. Morgan (2002) identified a picture test as a perspective that prompts one's awareness of the stimuli used.

In general, the Science Achievement Test was developed around ten questions to which some of the questions expanded to other sub-questions that needed further answers and explanations. Therefore, the test had a total of 30 items (see Appendix E). As earlier mentioned, the instrument went through several criticisms with a sequence of refinements for a better instrument. After a series of corrections and amendments, six advanced science education experts were requested to rate each item of the questions in terms of relevance, clarity, and simplicity of the language for grade seven learners. Hence, the reliability and validity of the instrument were obtained using a modified Spearman's Rank-Order calculation. Each item was rated from 1-5, where 1 indicated - Very Poor; 2-Poor: 3-Good; 4-Very Good, and 5-Excellent explanation. Using pair rating order, the raters agreement between similar raters stood at 0.99 and the pair difference was 0.98. Accordingly, this demonstrated strong content and construct validity of the instrument.

3.6.2 Cloze Test (CT)

Cloze Test is an instrument designed for learners to supply appropriate words that were removed from a passage to measure one's ability to comprehend a text (Brown, 2013; Cutting & Scarborough, 2006). This is a kind of science language activity (CAPS, 2014) that provides evidence on how easy or difficult a text is to be read and understood among learners with different language backgrounds. Ogunniyi (1999) affirms that knowing and understanding a language involves more than just having a bunch of formal symbols, it involves having an interpretation, or a meaning attached to those symbols. In other words, when information is missing, a person will use their past experiences or background knowledge in combination with critical thinking and reasoning skills to fill in the missing gaps (Melody, 2017). Although, there were critics about the cloze test (Pearson & Hamm; 2005). However, Kleijn, Pander Maat & Sanders (2019) indicated that cloze test measures beyond sentence boundaries, more so the configuration of a cloze test determines its validity.

In this study, a cloze test was used as a source for data collection because it creates room to investigate learners' reading level and comprehension about the phenomenon in the discussion, in as much as language is involved. The instrument was developed in a short paragraph with 18 gaps. The learners were instructed to restore the missing words. Hence, choosing from the correct words provided in a box. The short paragraph presented learners with information that explained the law of conservation of energy, forms of energy, and energy transfer from one form to another (see Appendix F)

The correlation of the rating from six experts based on the modified Spearman-Rank order stood at 0.98 and a pair rate difference of 0.96.

3.6.3 Argumentative Task

This argumentative task was prepared by adopting the ideas discussed by (Ogunniyi, 2007a, 2007b; Toulmin's, 1958, 2003; Kuhn 2010, 1993; Renitskay et al., 2008; Newell & Beach, 2011) that intrudes both logical and non-logical interpretation of phenomena. The learners were engaged cognitively towards reasoning and critical thinking as they unfold their conceptions. The task was developed using different scenarios. Each scenario depicted a kind of real-life scene people encounter that proves the law of conservation of energy (see, Appendix C). The dialogic interactive content that appeared in the task was conveyed such that it would not only influence students learning within the social context but also helped students to internalize the communicative mode that transpired during the activity (i.e., from oral group discussion to a written task performed individually).

The questions were asked such that the learners would identify different levels of Toulmin's argumentative patterns that transpired in the scenario. This involved logical reasoning that does not only involve reading but thinking critically and writing. Klein & Boals (2001) and Smith (2013) affirm that writing improves cognitive skills, intellectual vitality, and concretise abstract ideas as it connects the dots in the learners' knowledge.

However, the tasks also went through a rigorous validation process by the same judges. Using Spearman's Rank correlation, it stood at 0.98 and a pairwise difference of 0.96 with an indication of strong content and construct validation.

Hence, the argumentative task was administered at different intervals of the intervention. The same task was first administered to individuals and later to a smaller group and then whole class discussion. It was first approached individually such that learners would personally express and defend his/her claims. At the individual's activity, CAT assured that a kind of internal argument or conversation erupts within the learner's mind at a point and he described that point as self-taught (Ogunniyi, 2007).

Also, the smaller groups dialogued their different views, this prompted a whole class discussion held at the end of each task. The discussions inspired them to examine their argument and conceptions. At that point, cognitive-intuitive conceptions were expected within the learners' mind as described by CAT (Ref. Chapter two) when dealing with conflicting scientific concepts with everyday experience (Ogunniyi, 2007) as such, different series of argumentative activities data were drawn for analysis.

3.6.4 Idea about Conservation of Energy Questionnaire (ICEQ)

The General Conceptions of Conservation of Energy Questionnaire (ICEQ) was designed and used to collect grade seven learners' conceptions of conservation of energy before and after they have been exposed to DAIM. The content of the instrument was derived from the Natural Science curriculum as well as other relevant textbooks.

The questionnaire was developed in two sections that include both closed and open-ended item questions. Section A comprised of closed-ended and Section B was an Open-ended question. Section A has developed around 14 questions to which the learners were expected to express their response choice with either in Agreement (A), disagreement (D), or Don't Know (DK) as the case may be. It was utilized to assess the grade seven learners' conceptions about conservation of energy, as well as to assess their views and conceptions about the law.

Section B was an Open and Close-ended question made up of 10 items that investigate the learners' personal view and knowledge about the law of conservation of energy (Appendix G). The questionnaire made a total of 24 items to which was rated by the same panel, using Spearmen's inter-rater coefficient, it stood at 0.99 and a pair rater difference of 0.98.

3.6.5 Individual Attitude towards Science Questionnaire (IASQ)

Numerous studies have attempted to explain attitude (e.g., LeVine, 2010; Marchetti, 2018; Rose, 1998) as a process of individual consciousness that determines the real or possible activity of the individual in the social world.

The Individual Attitude towards Science Questionnaire (IASQ) was inculcated into this study as a need. For the purpose of setting a yardstick and evidence during data analysis to articulate learners' comments based on their responses in other instruments such as SAT, Argumentative Task and Idea about Conservation of Energy Questionnaire, some researchers (Anggoro, Sopandi & Sholehuddin, 2017; Hacieminoglu, 2016; Osborne, Simon & Collins, 2003; Weinburgh, 1995) argued that learners' comprehension of knowledge depends on their attitude. Therefore, there was a need to explore learners' personal interests of choice, feeling, and opinion towards conservation of energy by looking into their attitude to science.

Studying science is a thing of interest (Krapp & Prenzel, 2011) irrespective of numerous factors that might affect learners' interest and attitude towards science. Attitude and interest pervade a large proportion of one's behaviour. There must be an interest before such factors could influence it. Prior knowledge and experience shape the learning process, which in turn affects a learner's attitude (Baldwin, Ebert-May & Burns, 1999).

Although, some learners were found naturally engaged (intrinsic) with science while others could be as a result of self-concept or the scientific benefits which Wang and Liou (2017) described as utility value. Otherwise, one's cultural beliefs or some dynamic psychosocial factors involving cognitive conflicts in the assimilation of scientific concepts with everyday experience (Ogunniyi, 2007a) could as well form a determining factor.

Therefore, this attitude test comprised of 18 items (see Appendix H) that were structured to find out their pre-and post-test attitude towards science. If there would be a change after administration of treatment using DAIM as well as their response in relation to other instruments, then the notion that their response could be as a result of a lack of interest in observing and learning science and vice versa.

In maintaining the rule of research, the instrument was also evaluated and rated by the same six experts. The pair rater correlation and inter-rater difference stood at 0.99 and 0.96, respectively. This indicated a strong content and construct validation, by using Spearman's Rank Formula.

3.6.6 Classroom observation

Classroom Observation is one of the methods I used to collect data by taking a step-by-step note of classroom discussions and interactions among learners while implementing DAIM. Observation is known as one of the key components that enhances the quality of teaching and learning within the classroom, but most times are taken for granted (Lasagabaster & Sierra, 2011; Myers, 2012).

In this study, an observation was carried out using a carefully structured set of steps and instruments. The argumentation lesson classroom observation sheet was designed, and it was used as a rating scale and checklist during a classroom observation. The rating scale (with numbers) shows the frequency of actions that took place during classroom teaching with DIAM (see Appendix D). The numbered scale does not conform to a negative judgment of the quality of actions displayed by learners. Neither does it target who wins or who loses. Rather it represents the frequency of the learners in the argumentative discourse of small groups. It also organises the manner of their adaptability to the elements of arguments as well as the level of each group's involvement.

The observation sheet also went through the validation process. Six science experts rated each item of the rubric on a scale of 1-5. The pair rater correlation and inter-rater difference based on Spearman Rank Difference stood at 0.91 and 0.89, thus showing strong content and construct validity. As indicated, an experienced observer in the field of science education conducted the observation during the argumentation lessons, and the data collected were analysed.

3.6.7 Video and audio recording

The videotape and audio tape were used to document and capture first-hand information during the intervention process. Some vital comments indicated by learners pertaining to their conceptions of conservation of energy while answering questions and during discussions were captured as supporting data. Their body language and language translation were very useful during data analyses and data interpretation.

3.6.8 Interview

This was to enable the learners the freedom to express their views. Furthermore, a group interview provided the opportunity for the exchange of views among individuals who share similar ideas on topics of mutual interest. It shows the centrality of human interactions for knowledge production and emphasizes the social situatedness of research data (Kvale, 1996).

On this account, a group interview was organized among the group leaders in this study. It was a written interview incorporated with discussions. The interview was made up of ten structured questions (Appendix I). The interview was carried out in such a manner to save time and also to yield a wider range of responses, unlike the individual interview. Moreover, the leader knows the needs of their group members and could give an account of their group views which created varied opinions, regardless of whether or not the group leaders were able to communicate clearly in English or in combination with their mother tongue. It was conducted to gather information for qualitative analysis and to create a free atmosphere for learners to state their views. Cohen, Manion and Morrison (2007) agreed that group interview detects how learners support, influence, complement, agree and disagree with each other, based on their knowledge about the subject content.

Furthermore, the interview provided ample opportunities to learn more about world views and as a means to build up a cordial relationship between the researcher and the learners for them to feel free to air their views with respect to their conceptions about conservation of energy. The instrument was also evaluated and rated by the same six experts. The pair rater correlation and inter-rater difference stood at 0.97 and 0.96, respectively. This indicated a strong content and construct validation, by using Spearman's Rank Formula.

Importantly, the data were analysed qualitatively using a narrative interpretive process. Then the findings from the interview were epitomized with selected verbatim quotes.

3.6.9 Jotter

A jotter is a small notebook for writing down points during lessons. Longenecker (2010) identified the use of jotter as an act of training initiative, that could be helpful, unobtrusive, and a practical tool for invoking in the learner reflection-in-action and reflection-on-action.

Hence, the learners were provided with a jotter to enable them to jot down what they have learnt and their views about each day's lesson (including things they were unable to communicate in a group, and their personal experience). The information written in those jotters was collected and later returned to them. They served as a source of data both in their conceptions about conservation of energy, explore their interest in the new teaching method (DAIM), and their attitude towards science. Therefore, jotter was included as a source of data that enriched the findings of the study.

3.7 Research Procedure Using DIAM (Build-Up-Activity)

It would be interesting to inform the reader at this juncture that the learning pattern and level of exposure between the learners of the 1980s and 21st-century learners (present-day learners) were quite different. This was as a result of present-day learner's level of exposure to digital gadgets and diverse patterns of learning which pre-empted the uniqueness of the content of each instrument used in the study. The uniqueness was to engage them with critical thinking, discussion, and writing of argument (Kuhn, 2016). It was noted that most of those learners pretend and make use of their cell phones in the classroom to google and compare whether what the teacher is saying is in line with what google provided for them, hence bringing about distractions among the learners.

Secondly, these learners might have been exposed to different learning methods or similar methods that do not seem new to them. For instance, they might be familiar with group work activity which was part of DAIM's strategy. Therefore, those taught were guided and monitored to cub any hindrance to the findings of this study. Therefore, the grade seven learners' knowledge about group work pre-empted the researcher to group the learners herself with stated-out rules. The idea was to avoid noise making and lack of concentration as well as to inculcate some values in them such as respect for one another, paying attention, good listening habits especially during other learners' contributions, etc. Therefore, each of the instruments was structured to meet the aim of the study as well as the theoretical framework under which the study was bound. As previously mentioned, instructional learning was guided by DAIM.

Hence, the study lasted for six (6) weeks within which two days were set aside in a week for data collection. Ideally, lesson periods at the targeted schools were 30 minutes. The study was assigned double periods (1hour) per day in each school, for a period of six weeks. On the first day of the first week of the study, the pre-test data were collected with the Science Achievement Test and Cloze Test. This lasted for one hour. On day two of the same week, (Period: 1 Hour) another set of pre-test data was collected using the Idea about Conservation of Energy Questionnaire (ICEQ) and Individuals Attitude towards Science Questionnaire (IASQ) test after which the intervention commenced from week 2 – week 5 of the study.

This study was guided by a structured lesson plan that constitutes the Instructional Component and Context that was required for the learning (see Appendix B). During the intervention, learners were exposed to a series of lessons using DAIM. The learners were pedagogically engrossed with the new frame of activities. They were introduced to the meaning and use of argument in scientific discussions (Conservation of Energy). This was done to improve the learners' knowledge and argumentative skills within the study. Also, to enable learners to get familiarized with the identification and use of a claim, evidence, and rebuttals during classroom discussions.

This was further incorporated with the individual tasks and group tasks that were presented to the learners during the lesson (Appendix C). These were implemented by using (Bricker & Bell, 2009; Kuhn, 2010) ideas of teaching argumentation: by drawing examples from their personal/self-interaction (intra-argument). Consequently, they proceeded to inter-social argumentation (everyday conversation with friends) before migrating into scientific argumentation on conservation of energy. As the lessons progressed, those Toulmin's argumentative elements which include a claim, evidence, warrant, and counter-claim were gradually applied during discussions for easy usage and learners' familiarisation of the terms.

As earlier mentioned, the approach was structured to draw in both TAP and CAT's logical and non-logical views alongside their conceptions and perceptual differences about conservation of energy. The engagement in a scientific discourse enabled them to evaluate their arguments and argument of others as they engage in learning (Kuhn, 2010). This improved creative and critical thinking.

From this perspective, DAIM formulated a form of argumentation framework that pursues to enhance learners' ability to reach consensus where feasible. However, any consensus reached should not be at the expense of changing or replacing (subdue or subsume) learners' beliefs with the scientific belief; rather learners should be made aware of the various worldviews on which a particular claim or argument may or may not be appropriate (Ogunniyi, 2009).

As was shown in figure 1.1, the Instructional Strategy used for Implementing stages of the Dialogical Argumentative Instructional Model (DAIM). The five (5) stages were also explained as follows:

Stage 1: learners were approached with an individual task or given questions to tackle (argumentative task). At this stage, a sort of "internal argument" or "conversation" emanates within their minds (at the micro-neuro-psychical level) where the individual's working memory (reasoning) and consciousness are expected to be cognitively more active. There is an assumed co-existence through the process of conceptual appropriation within the individual (Ogunniyi & Onwu, 2007).

Stage 2: This is the stage where the argumentative function erupts. The individual evaluates his/her reasons in a dialogic context and more confident to argue with others. This takes place at the macro-level. His/her thought or self-conversation is brought into a social setting involving a small group of people arguing and discussing a given task (inter-argumentation).

Stage 3: The group leaders of each group present their group decision to the entire class for further debates and discussion. It is assumed that good listeners distinguish reliable, truthful information from potentially wrong information. Some of the learners rebutted and presented their claims outrightly at this juncture.

Stage 4: At the fourth stage, the teacher mediates the discussions. This is known as trans-argumentation.

Stage 5*:* This involves cognitive harmonization. After all other stages have been successfully achieved, an evolving cognitive activity is already in progress in the mind of the individual as arguments and counter-arguments were presented.

DAIM illustrates three layers of conflict resolution that emanates within the learners' worldview and to some extent within the scientific community of practice, namely:

- At/from the individual or self-conversational level (intra-argumentation);
- to the small group - family level (inter-argumentation);
- And at the whole or community level (trans-argumentation).

Within these three levels, the learners were expected to conceptualize their thoughts about the conservation of energy. Also, DAIM enhances learners' effectiveness in mediating and harnessing misconceptions, and the ability to build a merger between the school science and learners' knowledge objectives and worldview to be consolidated.

By so doing, they depend on their own judgment (Ogunniyi, 2007). They become self-regulated in that activity as more convincing evidence erupts which made some of them abandon certain thoughts, improve their thoughts, as they keep on modifying their thought until the finest of it all. This could be referred to as learner causal reasoning and that is how most learning takes place among 21st-century learners.

Hence this present study prepared an activity that engages learners with the task that spurs their conceptions and involves thinking, evaluative thinking, and re-evaluate a given task until they individually and collectively come to a consensus on an answer to a given task. Therefore, the use of appropriate activities and pedagogical strategies was to enhance learners' conceptions of conservation of energy. This study lasted for 6 weeks. On day 1 of the sixth week of the study, a post-intervention test was administered, and interview data were collected; Science Achievement Test and Cloze Test were administered to learners for data collection. On day two (Period: 1 Hour,) another set of post-test data was collected using a questionnaire, attitude test, and interview. This was done after the intervention. The interview was a written interview. It was carried out by the group leaders for the sake of time; the leaders were five in number and through that process, data was collected for the study.

3.8 Data Analysis

All data collected during the study were analysed qualitatively and quantitatively. The pre-test and post-test data were presented using descriptive and inferential statistics. The quantitative data was calculated using Statistical Product and Service Solutions (SPSS) version 20 for accuracy of values while qualitative data were interpreted in words.

3.8.1 Analysis of the questionnaires

The questionnaires (IASQ, SAT, and ICEQ) were analysed using the process of open coding technique which allowed to uncover prominent themes that aligned in answering the research questions. Corbin and Strauss (1993, 2003) described open coding as an interpretive process by which conceptually similar interactions could be identified and grouped to form categories and subcategories. This approach was utilised because of its analytic procedure in providing insights through standard ways of interpreting phenomena reflected in the data. For example, learners' responses to each question were compared with one another to identify for similarities and differences. Each theme was then given a conceptual label. In other words, similar responses were grouped to form a theme.

Also, Silverman (2001) approach of using categories and frequencies were implemented for proper analytic clarity. This is where the content analysis is used to establish categories i.e. by counting the number of those similar responses that formed a theme in the item of text by presenting it in numbers, frequencies, and percentages. It is a way of summarizing a related test into explanatory categories presented in a tabular form.

Furthermore, though the Contiguity Argumentation Theory (CAT) served as one of the theoretical constructs underpinning the study it also served as a unit of analysis for describing the cognitive shifts that occurred among the subjects as a result of the instructional strategies to which they might have been exposed. These techniques were followed simultaneously in this study to enable the researcher to present sensitive issues and develop new insights by breaking through standard ways of thinking about conservation of energy as reflected in the data. The responses written in

Xhosa were not left out they were carefully translated into the English language and fit into the analysis.

3.8.2 Analysis of classroom observation

A classroom observation checklist was developed to determine the learners' ability to participate during classroom teaching with DAIM. The data collected from classroom observation answered research question number 2. However, five different argumentation lessons were observed and recorded to determine learner's involvement, progression, and manner of their adaptability to the elements of arguments during group discussions in all the lessons. At this stage, the data collected from individual and small group activities were analysed to show how learners applied the first-three levels of TAP in their discussions and CAT's cognitive intuitive notions were also identified. Furthermore, five performance standard appraisal rubrics were created using a rating scale. According to Miller and Salkind (2002) rating scale is a scale on a continuum or ordered series of categories that is based on personal judgment, seeks to obtain an evaluation or quantitative judgment of personality, group, or institutional characteristics.

Therefore, a descriptive rating scale was used to analyse the observation. The rating scale shows the statement of actions that meet the desirable argumentative classroom discussions that took place throughout the intervention. They include: talking and listening to others; using elements of TAP arguments; constructing ideas using well-articulated and structured viewpoints; using the frequently counter- arguments to strengthen the stances taken by the different groups. These statements were then rated based on each group's frequency of actions in the following four levels: 0-silence, 1- very little, 2- some of the time, and 3- frequently. These actions simply show their progression and consistency in constructing knowledge during classroom intervention. Reflecting on the argumentation process of the group/individual resolving anomalies and embracing conceptual change, the analysis objectively demonstrates the proceedings that took place during the intervention that enhanced learners understanding of the concepts.

The video/audio recordings: provided me with the benefit of re-visiting the aspect of the classroom that I recorded; gave me more time to reflect on the classroom events and to pursue the answers I am looking for. Pirie (1996) affirms that video recording forms data when what is seen on the video suggests ideas and form the basis for interpretations. It is through re-examining the episodes, what went before and what came after that the real strength of video as data could be exploited. Therefore, the ideas were analysed using TAP levels of argumentation and CAT's categories of notions that exist in the learners' mind and to analyse classroom observation.

3.8.3 Analysis of the interviews

The interview was analysed to answer research question number 2. A group interview was conducted at the end of the study. The data collected were analysed to determine if the learners had a different or better understanding of conservation of energy with the new teaching approach (DAIM) implemented and whether their views and alternative conceptions were changed.

The interview was analysed using the narrative analysis method. According to Christopher (2017) narrative interpretation captures the literal word-for-word testimony of the participants. The narrative method was used because, what was told is often remembered and the meanings attached to it long, after the words on the pages cease to be (Cacciattolo, 2015). Therefore, the narrative method applied in this study provided means in which learners expressed their understanding of what they have learnt with DAIM and how they interpret the phenomena which they have experienced. Thus, the data were interpreted in light of the concrete purpose of the investigation.

3.9 Ethical Consideration

According to Cacciattolo (2015) an ethical consideration is a professional code of conduct that ensures the safety of all the participants and organisations involved in a research study. Akaranga and Makau (2016) indicated that ethical norms enhance the purpose of research which includes the dissemination of knowledge, reporting or saying the truth, and finally the need to counteract errors. These expressed how vital it is for a researcher to observe appropriate values at all stages while conducting research.

In that regard, this study was approved by the Ethical Clearance Committee at the University of the Western Cape. After that, a letter for permission to conduct the research in two Cape Town schools was approved by the Director of Research, Western Cape Department of Education

(WCED) in Cape Town. Consent was sought from the principals of the two schools, accompanied by official letters and personal visits to the schools. Before the study commenced, another consent letter was sent to the parents/guidance of those learners to seek their permission for their children's participation in the study. The learners selected to participate in the study were given consent forms to sign. All necessary information about the conduct of the study was discussed with them.

Fictitious names were given to the two schools and none of the learners' names were mentioned in the study. In this regard, the anonymity and confidentiality of the schools and the learners were maintained throughout the study. Also, the ideas and works from other authors applied in this study were cited using the APA method and referencing system accordingly.

3.10 Summary

This chapter elaborates on the methodological approach applied in conducting this study. It argued on its choice to adopt a mixed method approach that incorporates qualitative and quantitative approaches. It gave an insight into how this study is situated within the interpretive paradigm with reference to the two theoretical frameworks embedded in this study i.e., Contiguity Argumentation Theory (CAT) and Toulmin's Argumentative Pattern (TAP). The study employed a quasi-experimental (Non-equivalent groups) design that examined Grade 7 learners' conceptions of conservation of energy and was structured to assess pre-test and post-test measures to assess two groups of selected grade seven learners from two different schools that had similar backgrounds.

A group was used as an experimental group while the other served as the control group. The procedure for data collection and possible instructional strategies applied within the two schools were addressed. Also, the process for data analysis was pre-informed. Finally, the steps followed to cub certain pre-existing factors, and other influences were expressed within ethical consideration. All these were addressed to ensure that interpretations and the findings of this study were valid. Therefore, the following chapter will discuss and present a detailed analysis of the results.

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS, AND DISCUSSION

4.0 Introduction

This study aims at assessing the conceptions on conservation of energy among grade seven learners in two Cape Town schools. The previous chapter presented the methodology of the study. In this chapter, the results were presented and analysed. The interpretations of the results were reported in two frames: brief demographic characteristics of the participants; and the participants' responses to the research questions. The participants' responses were drawn from the collected data and the results were described, interpreted, and analysed using quantitative and qualitative procedures relative to the research questions listed in chapter 1. These questions are:

- What conceptions of conservation of energy (CCE) are held by grade seven learners at North Primary School and Metro Primary School?
- How effective is DAIM in enhancing their conceptions of conservation of energy (CCE)?
- Are their conceptions of conservation of energy related to their age, gender, or language?

The quantitative data were presented in tables and figures, with comments that describe the relevance of the data. The qualitative data were illustrated using excerpts and quotations from the raw data. Also, the data were explored using Toulmin's (1958/2003) Argumentation Pattern (TAP) and Ogunniyi's (2007a) Contiguity argumentation theory (CAT). These two frameworks also served as the units of analysis for the data. For ease of reference, the questions were used as the sub-headings to ensure that all the questions were given due consideration. Furthermore, other elements that promoted the implementation of the study were identified and examined through the interview, observations, and learners' jotters. After this, the interpretive summary for each section was presented.

4.1 Brief demographic characteristics of the participants

For an in-depth analysis of the responses, it is of importance to present a brief overview of the demographic characteristics of the participants, based on their gender, age, and language.

A total of 48 grade seven learners from the control and the experimental groups participated in the study and wrote the pre-test and post-test. Subtotal of 24 learners were from North primary school (experimental group). The other 24 learners were from Metro primary school (control group). The demographic characteristics distributions of participated learners are shown in the table below.

Table 4.1: Distribution of participants by their language, gender, and age

RACE	HOME LANGUAGE	OTHER LANGUAGE	GENDER	AGE	EXPERIMENTAL GROUP (NORTH PRI. SCH)	CONTROL GROUP (METRO PRI. SCH)	Grand TOTAL
			Boys	**11years**	-	-	0
				12years	2	2	4
Black	**IsiXhosa**	**English**		**13years**	4	7	11
				14years	1	-	1
			Sub-Total		**7**	**9**	**-**
			Girls	11years	1	1	2
				12years	7	4	11
				13years	7	9	16
				14years	2	1	3
			Sub-Total		**17**	**15**	**48**

It is evident from Table 4.1 that all the learners from both groups were Blacks and spoke IsiXhosa. Surprisingly, none of the learners indicated knowledge in any other language other than the English language. This is due to the fact that the English language was not only a subject in the curriculum but also was presumed to have been learnt in school, as it was used as a medium of instruction. Furthermore, Table 4.1 shows that seven boys from North Primary school and nine boys from Metro Primary School participated in the study. A total of 16 boys (i.e., a third of the total number) from both schools took part in the study. In addition, 17 girls from North Primary and 15 from Metro primary school (i.e., 32 or two-thirds) participated in the study.

Table 4.1 tabulated the age details according to gender so that a relative comparison could be made between the boys and girls. The last column of the table shows the total number of learners in a particular age group among boys and girls from both North Primary School and Metro Primary

School. The ages of the participants ranged from 11-year-old to 14year-old. A large proportion was noticeable among the 13-year olds. The least among the age groups were the 11-year-olds with a total of 2 learners, both learners are girls, each came from North primary school and Metro primary school, respectively. The 12-year olds from the two schools were made up of four boys and 11 girls (15 learners), followed by the largest age group of 11 boys and 16 girls (27 learners) who were 13 years of age. It can be seen that in both groups, only one boy and four girls i.e., five learners were 14 years of age. As is generally the case in the South African population, the number of girls was greater than the number of boys.

4.2 Conceptions of Conservation of Energy (CCE) held by grade seven learners.

The Science Achievement Test (henceforth, SAT) and learners' ideas on the Conservation of Energy Questionnaire (ICEQ) were used to determine the conceptions which grade seven learners held about conservation of energy. As stated in chapter three, the data on SAT and ICEQ were collected before and after the intervention (i.e., pre-tests and post-tests). However, before the instructional intervention, responses gathered from pre-tests were analysed; to answer the research question on the CCE. The efficacy or otherwise of the methods of teaching I used while teaching the two groups provided the data for analysis.

It is necessary to point out that the questions on the SAT did not deal only with the conservation of energy but also to prove the validity of the law of conservation of energy. Those questions emanated from learners' daily encounters and applications of energy. An open coding technique was applied for a clearer analytical process and insights into the data. Through a careful examination of responses from 48 learners, I independently identified several themes using an open code system based on open coding and the generation of categories (Ghebru & Author, 2017; Strauss & Corbin, 1990). Likewise, content analysis of the text was used according to Silverman's (2001) approach by establishing categories and then counting the frequency of instances of those categories that occurred relative to SAT items. The questions were analysed under some conceptual labels such as general knowledge and understanding about energy; pictorial identification of energy sources and energy flow; diagrammatic expression of energy transfer and; perceptions about the nature of energy as not being created or destroyed but as being transformed from one form to another.

However, before unveiling the learners' conceptions on conservation of energy, a simple statistical analysis was used to compare the experimental group (E-group) and the control group (C-group) scores at the pre-test stage. The results are presented in Table 4.2.

Table 4.2: E and C groups learner's pre-test conceptions of conservation of energy.

Group	Mean	N	Std. D	t-value	Df	t-critical
Pre-test Experimental	21.10	24	7.95	0.13	23	2.07
Pre-test Control	21.37	24	9.38			

Alpha at .05, Confidence interval=95%

It can be seen from Table 4.2 that the Experimental group had a mean score of (M=21.10, SD=7.95) and the Control group (M=21.37, SD=9.38). Based on the analysis, the t-ratio value of 0.13 obtained is less than the t-critical value of 2.07 at $p < 0.05$. Therefore, the hypothesis which assumed "the experimental group and the control group would be comparable" was retained and its alternative (null hypothesis) was rejected. It indicates that the difference was not statistically different. This implied that the two groups were comparable before the treatment (DAIM) was administered to them.

4.2.1 General knowledge and understanding of energy.

The first question in the Science Achievement Test (SAT) explored the learners' understanding of energy. The questions were aligned in consideration to the key word 'energy' which metamorphosed into conservation. Sefton (2007) contends that the keystone of energy is the conservation and without conservation, energy is meaningless. In support of this view, Takaoğlu (2018) indicated the importance of progressivity in teaching, he contends therefore that learners should first be taught the concepts, before the laws and the theories. In other words, learners perceiving the relationship between concepts would be able to learn new concepts more easily. Therefore, learners' responses on the general knowledge and understanding about energy were presented in themes as shown in table 4.2.1 below:

Table 4.2.1: Learners' general pre-conceptions of energy

ITEMS	THEME	PRE-TEST			
		CONTROL GROUP	Frequency	EXPERIMENTAL GROUP	Frequency
Q 1.1: What is energy (Amandla)	Energy is power/strength	///// ///// ///// //	17	///// ///// /	11
	Attributes energy with some characteristics of living things.	//	2	///// /	6
	Energy makes everything happen/work	/////	5	///// //	7
1.2. Where do we get energy from (sources of energy)?	Energy is from food	///// ///// ///// ///	18	///// ///// ///// //	17
	Energy gives life/movement/play	//	3	/	3
	Renewable and non-renewable sources of energy	//	2	//	2
	No response	/	1	//	2
1.3. How do we use energy in our everyday lives?	To live and work	///// ///// ///// ///	18	///// ///// ///// ////	19
	Energy in food	///	3	/	1
	Electricity	//	2	/	1
	For pleasure	/	1	/	1
	No response	-	-	//	2
1.4. Name three different forms of energy	Unscientific answer; food water, television, cooking, kettle, etc.	///// ///// ////	14	///// ///// ///	13
	Kinetic, potential, sound, light, etc	///// ///	8	///// ////	9
	No response	//	2	//	2

Table 4.2.1 above indicates different conceptions that grade seven learners had about energy. When asked what energy is (Question 1.1), about 17 (70.8%) of the learners in the control group indicated that energy is power/strength whereas 11 (45.8%) learners in the experimental group claimed that energy is power/strength. Also, 2 (8.4%) learners in the controlled group described energy with characteristics of living things while 6 (25%) learners in the experimental group, attributed energy with the characteristics of living things. For example, they claimed that energy is something that helps us to live, breathe, and move around. Although there were differences in the level of their responses to the question, it is evident that two-third of the learners from both groups had alternative conceptions about energy. The remaining 5 (20.8%) in the control group, as well as 7 (29.2%) in the experimental group, claimed that energy made everything happen/work. It is therefore important to review some of the learners' comments. For ease of reference, the inscriptions with learner C1 to learner C24 represent those from the control group while learner E1 to learner E24 represent the experimental group. Below are some of the excerpts from the learners' responses:

Learner C6: *Energy is the power that you have or strength.*

Learner C7: *Energy is when you have eaten food and then you get energy.*

Learner C24: *Energy is something that helps us to live, move, and breath.*

Learner E1: *Energy is something that you use for movement.*

Learner E2: *Energy is power*

Learner E18: *Energy is needed to make everything work, move or live.*

By defining what energy is, this study found that the majority of the learners from the E-group and the C-group used concepts such as power, strength, movement, and force. The present findings seem to be consistent with other research findings (e.g., Dalaklioğlu & Şekercioğlu, 2015; Herrmann-Abell & DeBoer, 2011; Opitz et al., 2014; Takaoğlu, 2018) which showed that students at all level express related concepts with energy. Takaoğlu (2018) holds the view that the common difficulty found in defining energy is that they discuss preparatory concepts about energy instead of energy. In the past, Watts (1983) argued that the term energy forms part of a loose descriptive and interpretative network of ideas. That such ideas and meanings presented by learners (preconceptions) were not simply isolated misconceptions but were part of a complex structure that provides a sensible and coherent explanation of the world from the learners' point of view and those ideas form a guideline during teaching.

There is considerable research evidence to suggest that words play a significant role in learners' communicational ability. Language is the key mediator of meaning between individuals and could by the same token be a source of misconceptions or internal cohesion in scientific learning (Rudvin & Spinzi, 2015). For example, someone being energetic is used in everyday expression which draws the related concepts to have a similar meaning; whereas it contradicts the scientific description of energy. However, in the Xhosa language, power, energy, force, and strength could be used in different situations to mean *'Amandla'* which also makes it difficult for learners to differentiate between the concepts. It is evident to suggest that the use of language similarities to express meaning within scientific concepts most frequently contributes to various misconceptions of the phenomenon. It is as a result that Leach and Scott (2000) contend that the learners' home language is a measure upon which new learning experiences are built. A reasonable approach to tackle this issue was introduced by Ogunniyi's (2007) DAIM as a teaching tool that could enhance learners' understanding of scientific concepts as well as clarify the disparities in their misconceptions.

Question 1.2 asked the learners to state the sources of energy. 18 (75%) of the learners in the control group indicated that energy emanates from food while 17(70.8%) learners in the experimental group also claimed that they got energy from food consumption. Some of the learners mentioned that 'energy drinks' (Powerade drink and other foods) were good suppliers of energy. About 2 (8.3%) learners in the control group and 2 (8.3%) learners in the experimental group correctly stated that energy comes from renewable and non-renewable sources of energy which was scientific. 3 (12.5%) learners in the control group and 3 (12.5%) learners from the experimental group claimed that they got energy from their muscles as they play, move around, and live. 1 learner (4.2%) from the control group and 2 (8.3%) learners from the experimental group did not respond to the question. Below are few excerpts of their responses from both groups:

Learner C13: *Energy comes from your muscles.*
Learner C36: *We get energy from the fuel that is called food.*
Learner C39: *We get energy from food, water, fruit, vegetables, or PowerAde drink.*

Learner 4: *We get energy when we exercise and play around.*
Learner E18: *We get energy from the food we eat.*
Learner E25: *We get energy from nature.*

Further, question 1.3 states: How do we use energy in our everyday lives? This is to excavate their thought on how they use energy. Almost two-thirds of the learners (77%) from both groups said that energy was used to live and do work. Their responses seemed to correspond with their conceptions that energy is power, strength, breath, food, etc. meaning that only when one's stomach gets filled that a task could be accomplished. This response is not far from the textbook definition that 'energy is the ability to do work. However, 9% of the learners from both groups claimed that the energy in food is what we use in our everyday life. About 6% believed that energy is used through electricity and the other 4% from both groups indicated that energy was for pleasure. The description of energy with the word ‘pleasure’ was not far from their understanding and their inscription of energy with food. Pleasure means feeling happy, experiencing some satisfaction, or enjoyment. Although living things are unique in that they have the inherent ability to transfer energy from the food they eat to another form. But their views though less scientific align with sociocultural values e.g., getting energy from food could give one a sense of satisfaction. Figure 4.1 below shows a response given by one of the learners:

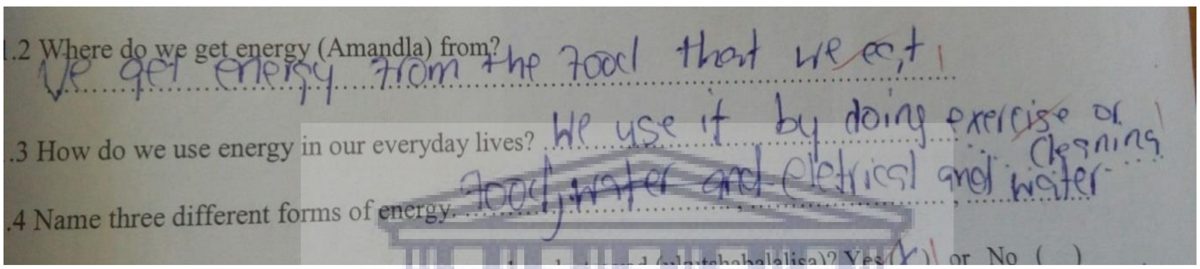


Figure 4.1. Example of an answer given by a learner on SAT items at the pre-test stage

When the learners were asked to name different forms of energy in question 1.4 as shown in Table 4.2.1 above. About 14(58.4%) learners from the control group gave unscientific answers which include; food, water, television, cooking, kettle, etc. whereas 13 (54.2%) learners from the experimental group also presented similar unscientific answers. Only 8 (33.3%) learners from the control group and 9 (37.5%) from the experimental group gave scientifically valid responses e.g. kinetic energy, potential energy, sound energy, light energy, etc. Coincidentally, 2(8.3%) learners from the control group and another 2(8.3%) from the experimental group did not attempt the question.

It is evident therefore that learners from both C and E groups shared similar views about energy. Their general knowledge about energy depicted unscientific and contradictory ideas about energy, though some did hold scientific views about the concept. However, the majority of the learners' associated energy with living things and human activities.

4.2.2 Learners' pre-test conceptions of energy sources and energy flow based on pictorial representation.

This section examined the learners' knowledge of where the energy came from (energy source) and how it flows, based on their interpretation of pictorial representations. The pictorial representation was supported by Edens and Potter (2001) who argue that pictorial representation promotes understanding of scientific concepts and explanations from a cognitive perspective. Therefore Table 4.2.2 tabulates learners' pre-test conceptions of energy sources and energy flow as follows:

Table 4.2.2: Learners' pre-test conceptions of energy sources and energy flow based on pictorial representation.

ITEMS	THEME	PRE-TEST			
		CONTROL GROUP	F	EXPERIMENTAL GROUP	F
Q 2: Name the type of energy source in each of the pictures.	Literal naming of the object (non-scientific)	///// ///// ////	14	///// ///// /////	15
	Scientific/correct identification of energy sources	//	2	//	2
	incorrect identification	///// ///	8	///// /	6
	No response	-	-	/	1
Q 4. (a.) what do you think will happen to the end of the metal you were holding after a short while when the other end is on fire?	4a. Correct description	///// /////	10	///// ///	8
	a. Incorrect description	///// ///// ///	13	///// ///// ///// /	16
	No response	/	1	-	-
(b.) can you explain what happened in the diagram?	4b. Correct description	///// ///// /	11	///// /	6
	b. Partial description	/////	5	/////	5
	c. Incorrect description	///// ///	8	///// ///// /	11
	No response	-	-	//	2
Q. 9. Name the different kinds of energy that a rotating fan is transformed into.	An acceptable and scientific answer	///	3	///// ////	9
	Incorrect and unscientific	///// ///// ///// ////	19	///// ///// //	12
	No response	//	2	///	3

Learners from both the control and the experimental groups share similar views that depict a lack of scientific understanding regarding the sources of energy. When the question on the pictorial representation of energy sources (Q.2) was examined in table 4.2.2 above, it shows that about two-thirds of the learners from both groups had a conceptual misunderstanding of the concept. A total of 14 (58.3%) learners from the control group and 15 (62.5%) learners in the experimental group literally named the objects (non-scientific) as depicted in the picture. It indicates that the learners' preconceptions were based on the features they saw on the diagrams. They did not relate the idea to the content of the concept being discussed. For example; the diagram that depicted Wind energy was named as a fan and some described the diagram as electric poles; Bio-fuel was named as mealies, grass, millets, crops, maize, etc.; Coal was named as stones, black rocks, etc.; Hydropower was named as a flow of water, river, stream, etc. It is evident that most of the learners in both the control and the experimental groups had misconceptions about the energy flow and sources of energy content. For example, in figure 4.2. shows an excerpt of the non-scientific response given by a learner below:

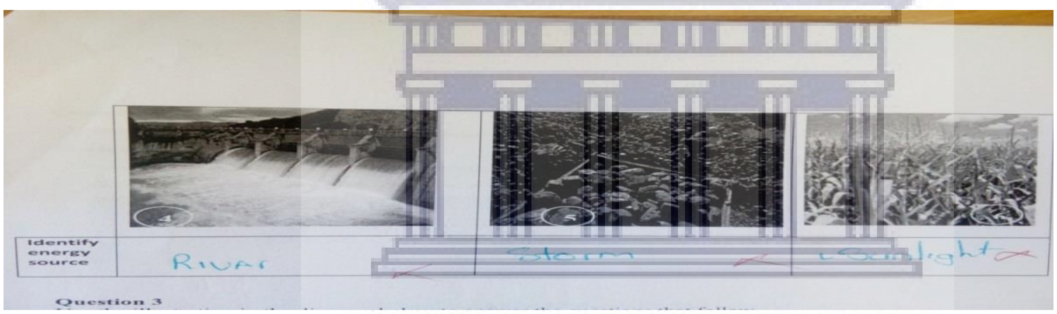


Figure 4. 2. An example of the pictorial representation of energy by learners at the pre-test

Although the described names given by most of the learners might not be wrong as it was exactly what they saw on the diagram, however, it shows that they do not have the idea that those items generate energy in real life. On a similar note, Takaoğlu (2018) indicated that the fact that the questions about energy sources have not been answered by most of the learners show that they do not have enough information about the topic. This might probably be the case because the other 8 (33.4%) learners from the control group and 6 (25%) learners from the experimental group gave incorrect identifications which were not related to the pictures and neither were their answers correct.

As earlier indicated, the expressions on the diagrams in figure 4.2 show that most of the learners had a limited understanding of the existence of energy in those objects and probably do not know the scientific description of energy in those objects. These imply that an inappropriate understanding of the fundamentals of a concept at the beginning of a study can interfere with subsequent learning. Considering the experimental description of energy flow in question four (Q4) as examined in table 4.2.2 above. In section A of question four: 13 (54.2%) learners in the control group were unable to explain what happened at the end of a bar metal they held when one end of the same metal was placed on fire (energy flow). While 16 (66.7%) of the learners in the experimental group presented an incorrect description of the energy flow (when one end of a bar metal was placed on a burning fire). Consequently, in section B of the same question four, about 8 learners (33.3%) from the control group and 11(45.8%) learners from the experimental group could not describe or explain the diagram and as such gave an incorrect description of what happened in the diagram. Therefore, 21% of the learners from both groups gave a partial description of the diagram while 4% did not respond to the question. The overall response to this question was poor. This reveals that learners from both groups lack a coherent understanding of energy sources and have difficulty applying them to different physical situations.

That is why the teaching of energy is expected to introduce the physical energy concept and there are several issues related to this expectation. The National Research Council (1997) contends that misconceptions are often deeply held and unexplained by teachers. Teachers therefore should review possible misconceptions among learners and use them to identify the need for a proper model before teaching.

In identifying different kinds of energy to which a rotating fan transforms into as shown in table 4.2.2 of question nine, it was evident that more than half (65%) of the learners from both groups were unable to supply the correct answers. They gave an incorrect and unscientific response to the question for example the majority of them mentioned the features they found on the pictures such as standing fan, remote buttons, air, new & old fans, etc. Only 25% gave an acceptable and scientific response by indicating sound energy, kinetic energy, wind energy, and mechanical energy, etc. while 10% did not even respond to the question. Below are few excerpts from the learners' responses (figure 4.3):

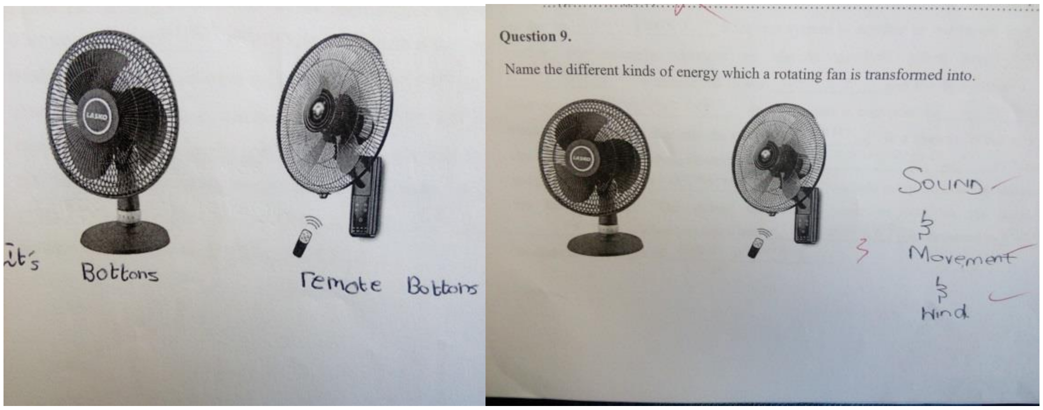


Figure 4.3. An example of learners' pre-test conceptions of energy flow is based on pictorial representation.

In general, the learners' preconceptions on Pictorial representation of energy sources and energy flow entertained misconceptions and limited conceptual knowledge. As Ogunniyi et al. (2004) have suggested, a variety of innovative instructional approaches should be used to foster conceptual understanding among learners instead of relying solely on traditional instruction.

4.2.3 Diagrammatic representation of energy transfer

This section investigates the learners' intuitive knowledge of energy transfers from one form to another during the conservation of energy. This conforms to Ogunniyi's (2007a) Contiguity Argumentation Theory (CAT) which suggests initial conflict between a learner's intuitive conception with the scientific conception which he/she is presented within the class. In this regard, the learner might ignore the latter or seek a way to resolve the conflict through a process of accommodation, assimilation, integrative reconciliation, and adaptation. To explore more of the learners' conceptions, some diagrams were used to explore their thinking processes. Fischbein (2002) asserts that diagrams are ideal tools for bridging the conceptual gaps existing between a learner's interpretation of reality and that of science. In this respect questions, 6.1, 7.1, 8.1, and 10 were used to determine this cognitive process (Table 4.2.3).

Table 4.2.3: Diagrammatic representation of energy transfer

ITEMS	THEME	PRE-TEST			
		CONTROL GROUP	Frequency	EXPERIMENTAL GROUP	Frequency
Q .6.1 List the picture(s) that you feel adequately describes the law of conservation of energy. Explain your reason	Correct identification with correct scientific reasons.	///	3	/////	5
	Correct identification with non-scientific/ literal reasons.	///// ///// ///// /	16	///// ///// ////	14
	Incorrect identification and non-scientific reasons	/////	5	/////	5
Q. 7.1 What do you think happened to the water in the kettle?	Correct scientific reasons.	////	4	/////	5
	Non-scientific/ literal reasons.	///// //	7	///// ///	8
	Incorrect response	///// ///// ///	13	///// ///// /	11
Q 8.1. Explain how energy flows among the living things in the diagram above?	The correct description of energy flow	///// ///	8	/////	5
	Partial description	//	2	///// ///	8
	Incorrect description	///// ///// ////	14	///// ///// /	11
Q. 10 Draw a diagram to show how energy is transformed from one form to another	Clear illustration	///// ///// //	12	///// ////	9
	In descriptive	///// ///	8	///// ///	8
	Partial illustration	////	4	///// //	7

Learners from both the control and the experimental groups share similar views regarding energy transfer. Question six presented the learners with different pictures and they were requested to list among those pictures the ones that adequately described the law of conservation of energy and state their reasons. As can be noted from the themes in table 4.2.3 above, about eighty percent of the learners from both groups identified the pictures correctly but could not state their views. However, a minority of the learners 3 (12%) in the control group, as well as 5 (20.8%) learners in the experimental group, expressed their views scientifically whereas others did not. It is evident that the majority of the learners in both the control and the experimental groups did not present their views scientifically rather they gave literal reasons for that. About 16 (66%) learners in the control group and 14 (58.4%) learners in the experimental group gave non-scientific reasons. Below are excerpts of their responses from both groups:

Learner C20: *It is because I wake up and eat food.*
Learner C15: *because the pictures are moving.*
Learner C7: *Picture C because I have to gym so I can be healthy.*
Learner E24: *because the pictures look good.*
Learner E18: *It is because I like to play soccer.*

Learner E12: *picture E shows that when you want to get the energy you have to eat*.

The preconceptions about the diagrammatic representation of energy transfer were similar to that of energy sources and energy flow based on the pictorial representation presented above. Their responses show that majority of them had no idea about the relationship between the objects presented in pictures and energy as a concept.

In question 10, the learners were asked to draw from their mind, how energy can be transformed from one form to another. It is noted that 12 (50%) learners from the control group and 9 (37.5%) learners from the experimental groups presented diagrams with clear illustrations of energy transfer. About 33% of both groups gave non-descriptive diagrams; this shows that their diagrams did not conform to the question asked. While the remaining 23% of the learners from both groups had diagrams that were partially illustrated; their diagrams portrayed limited demonstrations about energy transfer. However, their drawings provided the following types of imagery. See examples in excerpts below (figure 4.4):

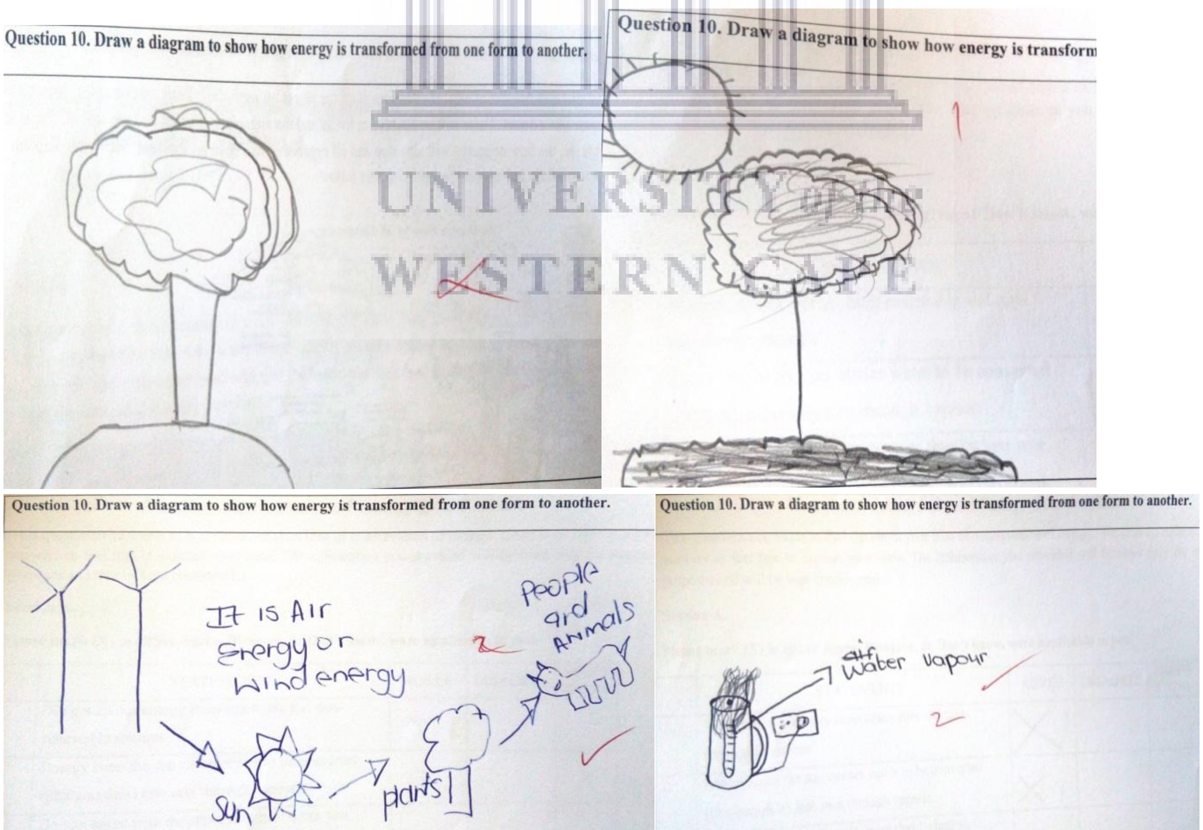


Figure 4.4. Diagrammatic representation of energy transfer.

The first diagram in figure 4.4 was classified as a non-descriptive diagram. In this regards most of the learners drew an object without any illustration of what the object was for. While the second diagram was partially illustrated, however, takes a long thought to connect to the information it portrays about energy transfer. The third and fourth diagrams gave clear illustrations and creative expression of energy transfer. It is evident that these illustrations show that majority of the learners from both groups had a pre-understanding of energy transfer but could not communicate their ideas properly. Diagrams are useful as alternative means of communication for learners who are experiencing problems in communicating their thoughts verbally. This is because, learners' thoughts determine their representations, interpretations and predictions, worldviews, and experiences. Hence, Evagorou, Erduran, and Mäntylä (2015) suggest that just as diagrams reflect complex phenomena that are not observable in other ways, they lead to the development of knowledge in science from the learners' perspective. Taking together, these findings Köse (2008) asserts that Drawings provide some useful information in teaching and learning processes, it recognizes misconceptions and, more importantly, provides an open-ended means of visual expression which would be difficult to accomplish with other assessment strategies. Hence the diagrammatic representation of energy transfer identified 33% of the learners from both groups that had misconceptions about the phenomena.

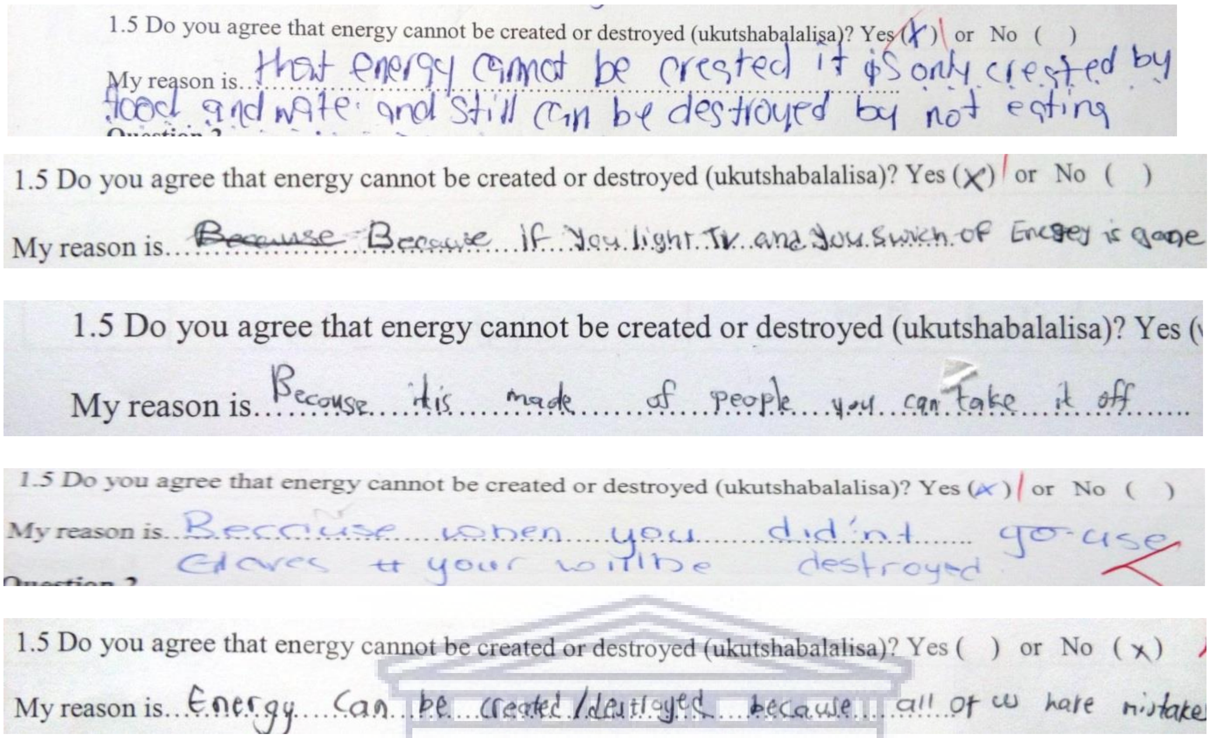
4.2.4 Learners' perceptions of 'energy as not created or destroyed'.

It has been reported that conservation of energy is an essential law in physics which everything that happens in the universe obeys, but its abstract nature makes it more prone to different alternative understandings among learners. To gain a deeper understanding of how grade seven learners build their knowledge on a difficult and important concept; conservation of energy, this study looked at their perceptions of 'energy as neither created nor destroyed' which was a critical statement conveyed by the law of conservation of energy. The learners' preconceptions of the concept were drawn from questions 1.5, 7.3, and 8.4 of the SAT. See Table 4.2.4 below:

Table 4.2.4: Learners' perceptions of energy as neither created nor destroyed.

ITEMS	THEME	PRE-TEST			
		CONTROL GROUP	Frequency	EXPERIMENTAL GROUP	Frequency
Q 1.5 do you agree that energy cannot be created or destroyed? Give your reason.	Energy can be destroyed/created and lost	///// ///// ///// /	16	///// ///// ///	13
	Energy cannot be created/ can be transformed	///// ///	8	///// ///// /	11
Q 7.3 the heat has been converted into another form as the law of conservation of energy suggests? Yes or No. state your reason.	Correct identification with correct scientific reasons.	///// //	7	///	3
	Correct identification with non-scientific/ literal reasons.	////	4	////	4
	Incorrect response	///// ///// ///	13	///// ///// ///// /	16
	No response	-	-	/	1
Q. 8.4 In case a cat dies, what do you think will happen to the energy in its body?	Energy would be transformed	////	4	///// ///	8
	Energy would be destroyed, decay/rotten	///// ///// //	12	////	4
	Energy will remain the same, stop/disappear	////	4	///// //	7
	Incorrect response	///	3	/////	5
	No response	/	1	-	-

The first item (question 1.5) in this category was a bit argumentative, although the Dialogical argumentative instructional model (DAIM) was not implemented at the pre-test level. However, it was expected that the argumentation happened intra-psychologically, that is, inside each learner's mind (Vygotsky, 1978). Ogunniyi (2007b) described this argumentation as a kind of internal argument or self-conversation that erupts within the learners' minds at a point and he described that point of self-taught as a micro-neuro-psychical level. Therefore, learners consideration of question 1.5 at this point were expected to "agree" or "disagree" and state with reasons if "energy can neither be created nor destroyed" Table 4.2.4 indicates that about 16 (66%) learners in the control group and 13 (54.2%) learners in the experimental group disagreed to the statement, they claimed that energy can be destroyed, lost and created. Below were some of the excerpts from the raw data provided by the learners in both groups (figure 4.5):


1.5 Do you agree that energy cannot be created or destroyed (ukutshabalalisa)? Yes (x) or No ( )
My reason is… that energy cannot be created it is only created by food and wate and still can be destroyed by not eating

1.5 Do you agree that energy cannot be created or destroyed (ukutshabalalisa)? Yes (x) or No ( )
My reason is… Because Because if you light TV and you swich of Energy is gone

1.5 Do you agree that energy cannot be created or destroyed (ukutshabalalisa)? Yes (
My reason is… Because it is made of people you can take it off

1.5 Do you agree that energy cannot be created or destroyed (ukutshabalalisa)? Yes (x) or No ( )
My reason is.. Because when you didn't go use Gloves tt your will be destroyed

1.5 Do you agree that energy cannot be created or destroyed (ukutshabalalisa)? Yes ( ) or No (x)
My reason is… Energy can be created/destroyed because all of us have mistake

Figure 4.5. Examples of learners' preconceptions of 'energy as not created or destroyed' in the pre-test stage.

The outlined reasons presented by the learners from both groups in figure 4.5 above, indicated some misconceptions about the conservation of energy. These misconceptions were not only based on everyday experience within their environment but also on the error that energy usage has had a negative impact on the scientific understanding of the law of conservation of energy. All the reasons presented by the learners seem to depend on the interactions that took place within their environment. For example, one of the learners claimed that 'energy can only be created in food and water and still can be destroyed by not eating'. This statement sounds reasonable in everyday experience. According to Hoover (1996) learners come to learning situations with the knowledge they gained from previous experience; hence this knowledge appears to contradict scientific ideas about the conservation of energy. The constructivists contend that all knowledge constructed from the learner's previous experience of which they construct their understanding of the real world should not be neglected, that through teaching, active attempts emerge to construct new knowledge (Donald, Lazarus & Lolwana, 2010; Jonassen, 1994; McLeod, 2008). On the other hand, only 8

(33.3%) learners in the control group and 11 (45%) learners in the experimental group conformed to the law and claimed that energy cannot be created but can be transformed from one form to another, with the reason that energy is a natural source.

Question 7.3 expected the learners to state with reasons if heat energy in a boiling kettle can be converted into another form as suggested by the law of conservation of energy? This question probes and expand on their ideas about the conservation of energy. About 60% of learners from both groups gave an incorrect response to question 7.3 and their comments were out of context, in this regard, 13 (54%) learners were from the control group while 16 (66.7%) learners were from the experimental group. A minority of 7 (29.2%) learners in the control group and 3 (12.5%) learners in the experimental group identified the activity with scientific reasoning. 4 (16.6%) learners in the control group and 4 (16.6%) learners from the experimental group identified the activity correctly but gave non-scientific and literal reasons about the conversion of heat to another form, they stated as follow:

Learner C4: *The energy got destroyed.*

Learner C13: *The heat energy is not converted because it has not been used and the water is reduced because the heat was too fast.*

Learner E15: *because the water did not disappear.*

Learner E20: *The water is still in the kettle.*

Learners, who responded scientifically from both groups gave similar responses such as *the heat energy has been converted into another form; the heat turned water into gas etc.* While some learners believe energy cannot be converted under any circumstance, sixty percent of the learners from both groups gave unrelated answers. One such unrelated answer given by a learner was "*my reason is that they can be some things that are good". I presume that* most of such unrelated comments were written to fill their papers instead of leaving their papers blank. However, it is evident that a remarkable number of learners from both groups had limited scientific knowledge about the conservation of energy.

In question 8.4, learners were asked, "In case a cat dies, what will happen to the energy in its body? This item aimed to find out to what extent learners are able to connect their understanding of energy conservation to a real-life scenario. The responses depicted in table 4.2.4 above gave a clear indication that the majority (73%) of the learners from both groups believed that the energy used is gone and gone forever. However, the number of learners in the control group was more than those learners in the experimental group who believed that the energy is destroyed, decayed/rotten. Only 4 (16.6%) learners in the experimental group whereas about 12 (50%) learners in the control group believed that energy is destroyed, decay/rotten. A similar response was presented by 4 (16.6%) learners in the control group and 7 (29.2%) learners in the experimental group; they claimed that energy in the dead cat will remain the same, stop and disappear. It is evident that most of the learners in both the control and the experimental groups did not believe that energy can be transformed. Below are some of the excerpts presented by learners from both groups:

Learner C5: *It will fall away on the ground and decay.*
Learner C19: *It will be destroyed.*
Learner C21: *I think it will rot.*
Learner E3: *It will end because is not still alive.*
Learner E14: *The energy will flow out and disappear.*
Learner E24: *The energy will stop.*

Statements suggesting that the energy would disappear, stop, become destroyed, lost, decay, be gone or dies, etc. do not conform to the scientific law of conservation of energy. These misconceptions held by the learners in both groups are examples of major concerns that have been pointed out by numerous researchers (e.g., Chabalengula & Mumba, 2012; Stavy, 1990; Takaoglu, 2018; Tatar & Oktay, 2007). Learners' misconceptions and conceptual difficulties encountered in this study have been a major challenge in teaching-learning of energy conservation. Lee and Liu (2010) argued that understanding energy conservation fully requires the integration of many other ideas. However, only 25% of learners from both groups indicated that energy can be transferred and 2% did not respond to the question.

The general view about grade seven learners' preconceptions on conservation of energy in this study, indicates a lot of contradictions emanating from different supporting concepts, a notable example is their misconceptions on energy concept which aligned with other concepts. A possible explanation for these findings may be that the learners' thoughts possessed a dominant notion because the concept of energy and conservation are multidisciplinary topics that apply to every aspect of human lives. It disconnects when taught in a different subject. Van der Linde (2010) contends that human conception becomes dominant when it is most adaptable to their situation. Although, it is easier to comprehend the existence of something that one can see and touch than something that exists but invisible as energy and its conservation. Tatar, et al (2007) affirmed that energy is an important concept that concerns our daily lives; learners' mistakes in usage can have a detrimental influence on the scientific comprehension of the energy conservation principle. The evidence presented thus far supports the idea that grade seven learners from the control group as well as the experimental group do have alternative conceptions of conservation of energy.

Further investigations were provided by using a questionnaire known as the Idea about Conservation of Energy Questionnaire, as shown below:

4.2.5 Learners' ideas about conservation of energy questionnaire

Learners' views on the conservation of energy were further collected with a questionnaire. As earlier discussed in chapter three, the Idea about Conservation of Energy Questionnaire (ICEQ) consisting of 14 items was developed to explore the learners' conceptions of conservation of energy using a Likert scale in terms of Agreement (A); Disagreement (D) and Don't Know (DK). The preconceptions about the conservation of energy were collected from learners in both the control group (C) and the experimental group (E). The learners were asked to respond to each question in the questionnaire. See table 4.2.5 below:

Table 4.2.5: Learners' ideas about conservation of energy (pre-test)

No.	STATEMENTS	Experimental group PRE-TEST			Control group PRE-TEST		
		A	D	D K	A	D	D K
1.	We get all our energy from renewable and non-renewable sources.	16 *66.6%*	8 *33.3%*	-	7 29.2%	7 29.2%	10 *41.6%*
2.	Energy from the sun causes water to be converted (jika/guqulela) into rain through vapour.	12 *50%*	3 *12.5%*	9 *37.5%*	16 *66.7%*	5 *20.8%*	3 *12.5%*
3.	Do you agree with the statement that "when you switch on the fan in your bedroom, the electrical energy gets converted (jika/guqulela) into mechanical energy which causes it to move?	15 *62.5%*	7 *29.2%*	2 *8.3%*	10 *41.6%*	7 29.2%	7 29.2%
4.	Energy is converted (jika/guqulela) from the food we eat to enable us to do various activities e.g. run, jump, and so on.	15 *62.5*	5 *20.8%*	4 *16.6%*	9 *37.5%*	7 29.2%	8 *33.3%*
5.	Do you think things would be different if energy is not conserved?	6 *25%*	9 *37.5%*	9 *37.5%*	5 *20.8%*	12 *50%*	7 29.2%
6.	Energy is converted(jika/guqulela) from one form to another therefore it cannot be created or destroyed (ukutshabalalisa)	13 *54.2%*	7 *29.2%*	4 *16.6%*	10 *41.7%*	10 *41.7%*	4 *16.6%*
7.	The Law of conservation of energy can be confirmed by experiment.	10 *41.7%*	5 *20.8%*	9 *37.5%*	10 *41.7%*	11 45.8%	3 *12.5%*
8.	The radio transmits electrical energy into a sound energy	19 *79.2%*	4 *16.6%*	1 *4.2%*	15 *62.5%*	7 29.2%	2 *8.3%*
9.	Heat is one of the most important forms of energy we come in contact with every day.	15 *62.5%*	9 *37.5%*	-	15 *62.5%*	8 *33.3%*	1 4.2
10.	Energy is stored in many stationary objects.	13 *54.1%*	7 *29.1%*	4 *16.7%*	11 45.8%	6 25%	7 29.2%
11.	The energy in motion is called kinetic energy.	8 33.3%	5 *20.8%*	11 45.8%	11 45.8%	4 16.7%	9 *37.5%*
12	The wind is one of the sources of energy.	15 *62.5%*	4 *16.7%*	5 *20.8%*	15 *62.5%*	5 *20.8%*	4 16.7%
13.	Energy cannot be destroyed (ukutshabalalisa) but it can be wasted.	10 41.7%	6 25%	8 33.3%	11 *45.8%*	10 *41.7%*	3 *12.5%*
14.	From all you know, do you think that the conservation of energy is absolutely true (awukulungelanga), and unbreakable (ayophuleki) law of nature?	8 33.3%	4 16.7%	12 50%	8 33.3%	6 25%	10 41.7%

The idea about the conservation of energy as shown in Table 4.2.5 above, was fully integrated from many other ideas on energy. According to Mclldowie (1995), energy conservation at any system/ level is based on many supporting concepts such as energy source, energy transfer, energy flow, and energy transformation. However, for lack of space and the massive data already collected, the questions and responses of learners in table 4.2.5 were carefully examined and further put into themes for ease of interpretation. The fourteen questions were reduced to three themes. They include; Sources and Forms of energy; Energy Transfer; and Conservation of energy. The sources and forms of energy were derived from items 1, 9, 10, 11, and 12. The ideas on energy transfer were derived from items 2, 3, 4, and 8. While the conservation of energy was derived from items 5, 6, 7, 13, and 14. These energy concepts have been identified as relevant with important ideas that can connect and assess learners' understanding of energy conservation and guide teachers in teaching and learning (Neumann et al. 2013; Nordine 2016: Opitz et al. 2017).

4.2.5.1 Themes derived from learners' conceptions of sources, transfer, and conservation of energy.

The theme was of major importance in finding out learners' ideas on where energy comes from and places where energy is stored. This includes sources of energy, how energy is transferred and conserved even after being used. In other words, the energy that can do work for us, are in different forms. The learners' conceptions were sequentially accessed. Findings were presented in table 4.2.5.1 below:

Table 4.2.5.1: Themes derived from learners' preconceptions of sources, forms, and conservation of energy

Themes	Items	Groups	Agreed (%)	Disagreed (%)	Don't Know (%)
Sources and Forms of Energy	1, 9, 10, 11, 12	**E**	55.8	27.5	16.7
		C	49.2	25	25.8
Energy transfer	2, 3, 4, 8	**E**	39.1	25.9	35
		C	52.1	27.1	20.8
Conservation of energy	5, 6, 7, 13, 14	**E**	39.1	25.9	35
		C	36.6	40.8	22.6

Note: C = Control group; E = Experimental group.

As shown in Table 4.2.5.1, the learners from the control group and the experimental group seem to have a similar view on this category based on their level of responses. Let us have a close look at each theme.

Learners' preconceptions on sources and forms of energy (Items 1, 9,10 & 11).

Five items examined the learners' understanding of sources and forms of energy in this category. The questions from these five items were drawn from different aspects of energy sources and forms (see table 4.2.5) to ensure a quality understanding of the concept. It was noted from table 4.2.5.1 that 55.8% of learners in the experimental group compared to 49.2% of the learners in the control group demonstrated a sound understanding of the concept. While 27.5% and 25% of the learners from the experimental and the control groups respectively, disagreed with the statement. Likewise, 16.7% and 25.8% of the learners from the same groups respectively indicated that they had no idea about the information sought. It is very pertinent to note that more learners from both groups responded positively to the question. Therefore, adding up the learners who disagree with the statement and those who had no idea about the information, it is evident that about forty-eight percent of the learners in both groups had a limited understanding of energy sources and forms.

Learners' preconceptions on energy transfer (Items 2, 3, 4, & 8)

On a similar view, four items were used to identify learners' conceptions about energy transfer. The majority of the learners from the C group demonstrated a good understanding of energy transfer, 52.1% of them gave appropriate responses. On the other hand, 39.1% of the learners from the experimental group agreed positively to the statements that describe energy transfer. On the same view about 25.9% and 27.1% of learners from the E group and the C group respectively, disagreed with the statements that described energy transfer and gave inappropriate responses. Likewise, 16.7% and 20.8% of learners in the E group and the C group respectively, had no idea about energy transfer. Those learners who had an incorrect expression of energy transfer, stated as follows:

> **Learner E7:** Energy from the sun does not cause water to be converted into rain through vapour.

Learners E14: I disagree, energy cannot convert the food we eat to enable us to do various activities e.g., run, jump, and so on.

Learner C5: I disagree with the statement that "when you switch on a fan, the electrical

Learner C21: The radio does not transmit electrical energy into a sound energy.

Learners' preconceptions on conservation of energy (Items 5, 6, 7, 13 & 14)

The overall responses from questions in these items (5, 6, 7, 13 & 14) were the most poorly attempted among other concepts in the theme. A total of 60.9% of the E group learners and 63.4% of the C group learners showed a lack of knowledge and incorrect expressions of conservation of energy. The following statements are representative of the learners' conceptions of conservation of energy:

Learner E12: *Energy can be destroyed and can be wasted.*

Learner C18: *From all I know, I think the conservation of energy is not absolutely true.*

The present findings seem to be consistent with other research which found learners' understanding of conservation of energy as unsatisfactory in terms of their performance in the conception of the phenomena (Dalaklioğlu & Şekercioğlu, 2015; Herrmann-Abell & DeBoer, 2011; Jin & Anderson, 2012; Opitz et al., 2014; Sefton, 2004). According to Herrmann-Abell and DeBoer (2011) learners in most cases experience more difficulty when applying a general principle to a specific real-world case than they did in recognizing the truth of the principle itself.

It could be noted that once a proper understanding is lacking there could be an alternative conception. However, only 39.1% of the learners from the E group and 36.6% of those from the C group agreed to the statements with a proper understanding of the conservation of energy.

In general, the comparison of the two results from both groups revealed some similarities in their conceptions. Although the two groups might seem different from each other, evidence also showed that the majority of the learners in both groups had misconceptions about the conservation of energy. Having taken note of the learners' pre-test conceptions about conservation before an intervention was administered; the next stage is to find out from the research question if the intervention administered had any positive impact on enhancing the learners' conceptions of the phenomena.

The learners' post conceptions of conservation of energy are discussed in the next section.

4.3 The effectiveness of DAIM in enhancing learners' Conceptions of Conservation of Energy (CCE).

As earlier indicated, DAIM is an instructional approach that is based on CAT. It creates a learning situation whereby teachers and learners are actively engaged in classroom discourses with the goal of reaching a collaborative consensus on a given issue. It allows learners to express their opinions freely, clear their doubts and even change their minds in the face of stronger arguments put forward by others (Diwu & Ogunniyi, 2012; February, 2014; Ogunniyi, 2011). Expressly, arguments offer enough opportunities for learners to clarify their misunderstandings and to improve their overall awareness of the subject matter.

Although, some authors have speculated that it is extremely difficult to achieve conceptual change, especially in concepts that have everyday experiences (like conservation of energy) that do not match abstract scientific thinking (Govender, 2011; Posner et al., 1982; Rankhumise & Lemmer, 2008). Therefore, in other to find out the truth about these perceptions and more, this study involved the adoption of DAIM.

The research question aimed at discovering if there was any distinction between the adjustments in conceptual perspectives of conservation of energy by the experimental group learners who were exposed to the dialogical argumentation instructional model (DAIM) as compared to the control group learners who were exposed to traditional instruction. The differences between the two groups were determined by using t-test statistics. The null speculation was once that there was no difference obtained in conceptual understanding of conservation of energy through the experimental group learners and the control group learners. The alternative speculation was that there would be a distinction between the two groups. In comparing the experimental and the control groups, the post-test results from Science Achievement Test (SAT) which expressed the subject content that constitutes the important facts about the concept was examined. This was in order to find out learners' understanding of the conservation of energy. To determine the changes that might have taken place after the post-test, Table 4.3. is used to present the results obtained in this regard:

Table 4.3: ***E and C*** **groups learners' post-test conceptions of conservation of energy**

Group	Mean	N	St Deviation	t-value	Df	t-critical	Sig. (2 - tailed)
Experimental	33.08	24	8.66	3.14	23	2.06	0.005
Control	25.54	24	8.14				

Alpha at .05, Confidence interval=95%

It can be seen from table 4.3. above that, the Experimental group had a mean score of (M=33.08) which is higher compared to the control group's mean score of (M=25.54). The ratio of t-critical was at 2.06 and the paired sampled t-test value was at 3.14 and gave a significance at 0.005. Due to the fact that the t-value at 3.14 is greater than the t-critical at 2.06, the null speculation was rejected. Therefore, the results above show that the experimental group that was exposed to the Dialogical Argumentation Instructional Model (DAIM) showed a higher improvement. The two groups were taught with equal determination and dedication but DAIM significantly showed a difference among the experimental groups compared to the control groups, who were taught using a traditional teaching method. The findings are highlighted below respectively.

4.3.1. Classroom observation for the experimental group

Knowing the fundamental nature of reality connotes absolute knowledge, and truth can simply be seen within concrete evidence. The quest for the truth is provided by the underlying classroom observation which provided a greater degree of reliability of the subjective and objectivity of data provided in this study (Cohen et al., 2013; Niaz, 2018). Classroom observation plays an important role during intervention with DAIM towards enhancing learning. My primary concern with observation in this study was to examine the nature of arguments and reasoning exhibited by the learners towards the collaborative process in understanding the conservation of energy.

4.3.1.1 Learners' argumentative skill and reasoning towards the understanding of conservation of energy.

The lessons on conservation of energy commenced with useful instructional information that was clearly explained to the learners. An observation sheet designed in a rating scale and checklist was the instrument used to validate the classroom observation. Data were collected in each lesson and I sought to find the frequency in which the learners improved in constructing knowledge in their respective groups. An example of one classroom activity is presented below:

Individual Activity

At this stage, the learners were provided with individual tasks. In one of the classroom activities (activity 4; on conservation of energy), a scenario was given to learners to read and respond individually to the task. The task aimed at identifying the learner's understanding of conservation of energy and their ability to identify important elements of an argument in a discussion as part of the teaching method. A sample was presented below:

Scenario 1

Asanda's mom bought a brand new cell phone, after reading the instruction she decided to plug the phone for it to be fully charged before she could turn it ON. Out of excitement, Asanda suggested to her mom, why can't you turn ON the phone to see if it will go ON or not? Her mom said no, it is a new phone so where will it get the energy to start with, I must create energy first. **Asanda:** Mom, can you really create energy?
Asanda's mom: Yes, why not? My child, you see, in life it is either we are creating things, or we are destroying things.
Asanda: Does that apply to energy as well?
Asanda's mom: Of course, it applies to anything.
Asanda: Mom, but our class teacher told us that energy cannot be created or destroyed, but can only be transformed…
Asanda's mom: If you say so, are you saying if I switch ON the phone it will start?
Asanda: Yes mom, I think so. Usually, new phones come with charged batteries.
Asanda's mom: Wow! It's ON…I didn't know that. You are so clever my daughter, high five!

The skills in this study included learners being able to identify a claim made in a discussion or sentence, counter a claim, and also being able to present his/her claim and defend it by providing evidence through discussion. By so doing, learners construct knowledge by reasoning, thinking, discourse, and be able to write an argument. Learners' reactions were presented below:

1.1 What do you think Asanda and her mom were doing?

The learners' individual views were as follows:

> Learner E1: *Asanda and her mom were arguing.*
>
> Learner E6: *They were talking about energy.*
>
> Learner E9: *They were discussing energy.*
>
> Learner E12: *They were doing creating or destroying things.*
>
> Learner E18: *trying to turn on the new phone.*
>
> Learner E20: *talking about creating and destroying energy.*
>
> Learner E22: *They were having a conversation.*
>
> Learner E24: *arguing and debating.*

These responses show that the learners were able to make a claim (Level 1) which is Toulmin's first element of argumentation. It could be noted that these learners identified the dialogue between Asanda and her mum. For example, learners E1, E9, E22, and E24 were able to make their assertion based on the reaction in the text which is the bottom level of argumentation skills.

1.2 One of your classmates thought that Asanda's mom was right to say she can create or destroy energy? Do you agree? (Yes) or (No), state your reason(s).

This question probed the learners' understanding of conservation of energy, which created 'a pulse and think before response'. The majority of the learners responded positively to the questions. However, few perspectives were expressed. The excerpts are presented as follows:

> **Learner1:** *No because energy cannot be created or destroyed. Energy is not destroyed; it can be created.*
>
> **Learner 2***: No, it is because energy comes from nature and it cannot be destroyed.*
>
> ***Learner 3:*** *No, because energy is nature, God created it not people.*
>
> ***Learner 4****: No, energy can be created and transformed*

Learner 5: *No, because we cannot create or destroy energy, it can only be transformed.*

These responses connote level 1 and level 2 argumentation skills. At this level of argument, the learners made a claim and provided grounds (grounds cloud be a data, warrant, reason, evidence, or fact that you can see) that supports a statement or claim. CAT described their perception at this stage as "dominant" (Dominant exists when one's strong belief or idea tends to subdue other thought systems and thereby create a sort of rival in between them). However, each learners' grounds were dialogued in the small group discussion to prove its scientific facts or views.

1.3. Copy the sentence in the scenario that shows the first claim made by Asanda's mom.

My findings showed that the learners were able to identify the claim made by Asanda's mom when she said *No, it is a new phone…, I must create energy first.* A further question was asked for the learners to make their claim and provide evidence. The question asked:

1.4. Where does the energy in a fully charged battery go when being used and after the battery is left empty? Interestingly, different views were expressed. The following is representative: (as stated below from their excerpts:)

Learner 1: *My claim: It will go out.*

My reason/ evidence: *because if you are using it every time your phone will get low.*

Learner 2: *My claim is that it will be destroyed.*

My reason/ evidence*: the battery was left empty and it cannot work again.*

Learners 3; *my claim: I don't know.*

My reason/ evidence*: I never knew about it.*

Learner 4: *My claim: the battery becomes flat.*

My reason/evidence: *It will not have the energy to light again until you charge it. Charging it is more like you eating to get energy.*

Learner 5: *My claim: It gets away and becomes low.*

My reason/ evidence*: Because some people's battery energy gets levelled up when charged.*

The learners' responses still conform within level 1 and level 2 Toulmin's argumentation skills. However, the learners confront the question based on what they perceive at the moment, for example, it was noted that some of the learners' responses (e.g., Learner 1 and 2) contradict the response they gave in question 1.2. CAT described this as 'dominant'. Most of the learners expressed their views based on the everyday common (literal) expression of energy dissipation. However, further dialogue on their responses took place at small group discussions.

Small group discussion

At this stage, the individual learners meet in a smaller group made up of 4 or 5 learners (labelled groups A, B, C, D, and E). The dialogue on each other's claims and grounds after which a collective decision was written down as presented in Table 4.3.1 below. However, for any member who objects to the group decision after a long discussion, the opposed comment was indicated on the box provided. The table below shows excerpts from activity 4:

Table 4.3.1: Small-group discussion on the conservation of energy

No.	Group	Claim (TAP Level 1)	Grounds/Evidence/Reason (TAP Level 2)	Reasons for your disagreement (Rebuttal) (TAP level 3)	CAT's cognitive-intuitive notions
1.1	A	they were talking about energy	-	-	
	B	Arguing	-	-	
	C	Arguing based on phone	-	-	
	D	they were discussing about energy	-	-	
	E	They were talking about creating and destroying things	-	-	
1.2.	A	No, we don't agree	No, energy can be created or destroyed	-	Dominant
	B	No, we do not agree with him	Energy cannot be created nor destroyed	-	Suppressed
	C	No	Energy cannot be created but can be transformed	-	Suppressed
	D	Yes, Agreed	It is a new phone so where will we get the energy to start it, I must create energy first.	-	Dominant
	E	No	Because energy cannot be created or be destroyed but can only be transformed.	-	Suppressed
1.4	A	Energy goes to the battery	It is a new phone.		Equipollent
	B	We are not sure	-		-
	C	It becomes low and the energy disappears, and it can be stored	It will not have energy until it is charged and full.		Dominant
	D	We don't know	We don't know where energy goes from the battery.	It goes down. The energy goes down the battery. It becomes power off.	Assimilated
	E	It will be destroyed	It is because the battery was left empty and it cannot work again.	-	Dominant

Table 4.3.1 above shows that learners were able to apply argumentation principles in their discussion. However, the learners displayed limited knowledge in their conceptions of conservation of energy. They expressed more of their dominant views about the concept. In question 1.2, the learners in group B, C, and E come to a consensus with a scientific thought that energy cannot be created or destroyed but can be transformed and it was assumed that the group's cognitive-intuitive conceptions were "suppressed" with a valid, predictive, empirically testable

evidence, that subdues the existing taught or dominant belief (CAT). However, in question 1.4 the same group of learners displayed limited knowledge, thereby presenting their grounds with non-scientific reasons.

Group presentation

At this stage, each group presented the outcome of their discussion to the entire class by the group leader or any chosen member of the group. I as the teacher stepped in and mediated the discussion. At the time of the presentation, there was agreement and disagreements among members of other groups as a result of their claims and pieces of evidence. Though each group was prepared to defend their answers and reasons, it was observed that, as the discussion escalated, more convincing evidence erupted, and some learners had to abandon their written points and improved their thoughts with the new ideas that emerged (most especially in question number 1.4 in table 4.3.7). Kuhn (2010) contends that learners' engagement in a scientific discourse enabled them to evaluate their argument and argument of others as they engage in learning.

The following excerpts are presented by the learners:

1.4. Where does the energy in a fully charged battery go when being used and after the battery is left empty?

Learner 1: *My claim: It will go out.*

My reason/ evidence: *it will go out through the sound of the phone and light.* (Suppressed)

Learner 2: *My claim is that it will be transformed.*

My reason/ evidence*: the battery will be left with energy, but some will transform to light energy, sound energy, and heat energy.* (Suppressed)

Learners 3; *My claim: It will be transfer.*

My reason/ evidence*: It will transfer to the air and light energy* (Suppressed)

Learner 4: *My claim: If the battery becomes flat and it will not light again.*

My reason/evidence: *It will be charged with electrical energy.* (Suppressed)

Learner 5: *My claim: It transforms and becomes low.*

My reason/ evidence*: It transforms to sound energy when ringing or people are calling you or when you use the touch light.* (Suppressed)

At this stage, according to CAT, the learners' notions were "suppressed". It means their thoughts were immersed with valid, predictive, empirically testable evidence, that overlap and subdue their existing taught or dominant belief. Remember, thought repeatedly interprets the phenomenological existence of an idea from a subconscious state into a conscious state of mind in any given situation. Therefore, the impacted knowledge remains in the learners' minds. These findings further support the idea of collaborative learning by Vygotsky who contends on the positive impact the instructional and social interaction had on the learners' intellectual reasoning during the process of learning.

4.3.1.2 Observable classroom activity with DAIM

Learners' participation in group discussions and their consistency in the use of different levels of argumentation in their discussions were observed and recorded. The recorded observation was used to determine what progress and development the learners had over the intervention period. Table 4.3.1.2 presents the trend in classroom activity:

Table 4.3.1.2: Classroom observation

ARGUMENTATION AMONG GRADE 7 LEARNERS (Group discussion)	GROUP CONSTRUCTION AND EVALUATION OF ARGUMENT																			
	Day 1				Day 2				Day 3				Day 4				Day 5			
	GROUP ACTIVITY				GROUP ACTIVITY				GROUP ACTIVITY				GROUP ACTIVITY				GROUP ACTIVITY			
RATING SCALE	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3
Talking and listening to others in groups			A B C D E					A B C D E				A B C D E				A B C D E				A B C D E
Use elements of argument in the conservation of energy discussion		A B D	C E				B D E	A C			A C E	B D				A B C D				A B C D E
Constructing ideas using well-articulated and structured viewpoints		A B C D E					E	A B C D			A B C	D E			E	A B C D				A B C D E
Frequent counter-arguing to strengthen either own group's views or other groups		A B C D E					C E	A B D			A B C D	E				A B C D E			A B C E	D
Reflecting on the argumentation process, group/individual resolving anomalies embracing conceptual change		A B C D E					A B C D E				A B C D E				A D	B C E			E	A B C D

Key: 0 – Silence; 1 – Not at all; 2 – Some of the time; 3 – Frequently; (A-E)- represents the different groups.

The rating scale on table 4.3.7.2 shows the frequency of actions that took place during classroom activity with DIAM. The numbers (0-3) represent the frequency of the learners' participation in each day's argumentative discourse and the level of each groups' involvement in constructing knowledge.

Day 1: As can be seen from Table 4.3.7.2 above, talking and listening to each other in a group on day one was a bit difficult as most of the groups were rated at scale 2 (some of the time) for not being consistent in contributing to the discussion. Most of them only managed to select a leader as some learners were not willing to open up in their group discussions. They demonstrated signs of insecurity. All they could do was to steer at each other. They listened to the teacher's instructions but still were unwilling to communicate their views. These reactions were noticed in other argumentative proceedings which were rated 1 (i.e., not at all). However, as days passed by the learners began to adjust in their groups and to demonstrate attributes of understanding. Their discussions and relationships with one another in their small groups become cordial and consolidated.

Day 4 & Day 5: All the groups were able to use elements of argumentation in the discussions they improved by constructing ideas using well-articulated and structured viewpoints. For instance, on the fifth day, all group leaders were able to speak with boldness as they presented their points and also listened to others as they spoke. The use of argumentative elements in discussing the conservation of energy became frequent and they used argumentative elements (claim, grounds, and rebuttal) in conveying their stand/points. Frequent construction of ideas by using well-articulated and structured viewpoints was identified on day five in all the groups. Learners from different groups were able to counter-argue one another's viewpoints during dialogue in other to strengthen their points. They also expressed the act of resolving anomalies and embracing conceptual change as clearly observed within the period. I (teacher) mediated the lessons, these were reflected in their post-test performance.

As previously indicated, the understanding of conservation of energy by observation and testing of ideas cannot literally be a process of transmission where knowledge is presented as a non-equivocal and uncontested fact transferred from experts to a novice (Osborne, 2010), describing a one way means of learning that comes from the teacher alone that exists within the traditional teaching approach. Rather, the teaching of conservation of energy as it manifests in our natural world should create an equivocal forum where learners freely contest/express their experience, world views, encounters, taught, and expression about conservation of energy through the use of argumentation tasks.

4.3.2 General knowledge and understanding of energy (post-test).

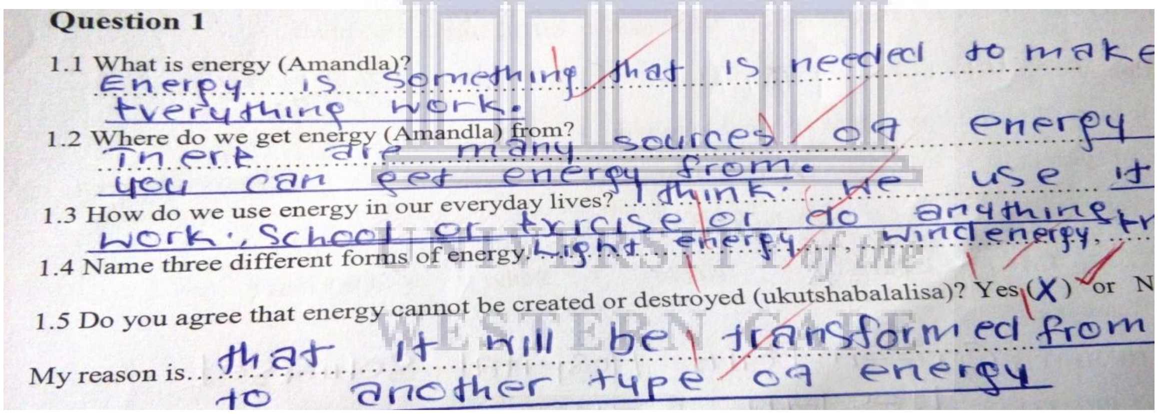
This section pays attention to the cognitive shift that transpired between the two groups in terms of their general knowledge and understanding of energy after they have been exposed to these two different teaching methods. Their conceptions on energy were reviewed, and their responses were presented in themes as shown earlier in pre-test analysis. See the findings in Table 4.3.2 below:

Table 4.3.2: Learners' general post-conceptions of energy

ITEMS	THEME	CONTROL GROUP (POST-TEST)		EXPERIMENTAL GROUP (POST-TEST)	
		TALLY	SUB-TOTAL	TALLY	SUB-TOTAL
Q 1: what is energy (Amandla)	Energy is power/strength	///// ///// ///// //	17	////	4
	something that helps to live/move/breath	/////	5	///	3
	Energy makes everything happen/work	//	2	///// ///// /////	15
	No response	-	-	//	2
1.2. Where do we get energy from?	Energy is from food/fuel/electricity	///// ///// /////	15	///// ///// ///	13
	Energy gives life/movement/play	////	4	///	3
	From muscles	/	1	-	-
	Renewable and non-renewable sources of energy/nature	///	3	///// //	7
	No response	/	1	/	1
1.3. How do we use energy in our everyday lives?	To live and work	///// ///// ///// //	17	///// ///// ///// /////	20
	We use energy by eating food	////	4	//	2
	Electricity	//	2	/	1
	For pleasure	/	1	-	-
	No response	-	-	/	1
1.4. Name three different forms of energy	Unscientific answer; food water, television, cooking, kettle, etc	/////	5	///	3
	Kinetic, potential, sound, light, etc	///// ///// ///// ///	18	///// ///// ///// ///// /	21
	No response	/	1	-	-

Table 4.3.2 is quite revealing in several ways. First, unlike the other pre-test table 4.2.1, both groups had almost the same number of misconceptions about energy but at the post-test, more scientific responses were identified among the experimental group than among the control group learners. In other words, many learners in the latter seemed to have maintained their previous worldviews. About 17 (70.8%) learners from the control group believed that energy is power; the other 5 learners maintained that energy is nothing other than something that helped them to move around, breathe, and to live; only 2 learners in the same group acknowledged that energy is needed to make everything work; after they have been exposed to the traditional teaching method.

It is noteworthy that after the intervention, about 15 (62.8%) learners from the experimental group understood that energy makes everything happen/work at the post-test level. Only 4 (16.7%) learners believed that energy is power after they have been exposed to Dialogical Argumentation Instructional Model (DAIM). DAIM aims at facilitating learners' scientific beliefs or reach collaborative consensus about diverse phenomena but not at the expense of their indigenous beliefs. In other words, it is concerned with increasing their awareness about when a particular worldview, claim or argument is most appropriate for a given context (Ogunniyi, 2009). There is evidence to suggest that a fundamental understanding of a concept can build upon learners' factual and metacognition knowledge. Jonassen (1994) suggests that "the growth of knowledge evolves through social interactions where different viewpoints were shared, and our perspectives change through collaborative learning. Below shows an example of a post-test excerpt of the experimental group learner:


Question 1

1.1 What is energy (Amandla)? Energy is something that is needed to make everything work.

1.2 Where do we get energy (Amandla) from? There are many sources of energy you can get energy from.

1.3 How do we use energy in our everyday lives? I think: we use it work, School or exercise or do anything

1.4 Name three different forms of energy. Light energy, wind energy.

1.5 Do you agree that energy cannot be created or destroyed (ukutshabalalisa)? Yes (X) or N

My reason is that it will be transformed from to another type of energy

Figure 6. Excerpt from an experimental group learners' knowledge of energy at post-test

The response from the excerpt above is evidence that learners have changed their view to more scientific thought. CAT described this kind of notion as Suppressed. That is when valid, predictive, empirically testable evidence, overlap and subdue the existing misconceptions or dominant beliefs in the learner's mind.

4.3.3. Learners' post-test conceptions of energy sources and energy flow based on pictorial representation.

This section presents the learners' understanding of energy sources and energy flow, after being exposed to different teaching methods i.e., DAIM (experimental group) and traditional teaching method (control group). Their responses to questions were presented in themes. It was noted that the post-test themes of the control group and the experimental group recurred within the dataset, relative to the pre-test response. Table 4.3.3 below present their responses as follows:

Table 4.3.3: Learners' post-conceptions of energy sources and energy flow

ITEMS	THEME	CONTROL GROUP (POST-TEST)			EXPERIMENTAL GROUP (POST-TEST)
		TALLY	SUB-TOTAL	TALLY	SUB-TOTAL
Q 2: Pictorial identification of energy sources	Literal naming of the object (non-scientific)	/////	5	/	1
	Scientific/correct identification of energy sources	///// ///// ////	14	///// ///// ///// ///// /	21
	incorrect identification	/////	5	//	2
	No response	-	-	-	-
Q 4. Experimental description of energy flow	4a. Correct description	///// ///// ///	13	///// ////////// ////	19
	a. Incorrect description	///// ///// /	11	/////	5
	No response	-	-	-	-
	4b. Correct description	///// /	6	///// ///// /////	15
	b. Partial description	///// ///// /	11	////	4
	c. Incorrect description	///// /	6	///	3
	No response	/	1	//	2
Q. 9 name three different kinds of energy which a rotating fan is transformed into	An acceptable and scientific answer	///// /////	10	///// ///// ///// //	17
	Incorrect and unscientific	///// ///// //// /	14	///	3
	No response			////	4

It is apparent from this table 4.3.3 that very few learners still held on to their misconceived thoughts on energy sources and flow. However, a higher number of learners from both groups responded scientifically to almost all the questions, though more positive responses came from the E group. For example; in question two (2), about 21 learners from the E group gave scientific and correct identification of pictorial representation of energy sources compared to the 15 controlled group learners who answered correctly and gave valid responses to the same question. These were against the two learners from each group who answered correctly at the pre-test level. About 5 learners literally named the objects (non-scientific) and the other 5 learners gave incorrect responses to the items; all from the control group. While only 1 learner literally named the objects (non-scientific) and 2 learners gave incorrect responses to the items; these learners were from the experimental group. The results of these findings indicated a great improvement in learners' understanding of the concept.

Another important finding was that in question 4a, where the experimental description of energy flow was probed to the learners. About 19 learners from the experimental group gave a correct description of the energy flow. This was against the eight learners who responded correctly at the pre-test level. Among the controlled group, 13 learners responded correctly to the same question at the post level whereas ten learners responded correctly at the pre-test level. This shows a 46 percent increase among the experimental group and a 12 percent increase in the control group. However, 11 learners from the control group gave incorrect responses to the questions whereas 5 learners from the experimental group gave an incorrect response to the same question.

In identifying different kinds of energy to which a rotating fan transforms into as shown in table 4.3.2 of question nine, it was evident that about 17 learners from the experimental group supplied the correct and acceptable scientific answers. Whereas 10 learners from the controlled group gave an acceptable and scientific answer. The percentage increase in the experimental group was 33 percent and 28 percent in the control group. It shows that the experimental group provided the largest set of significant clusters in the scientific responses received as shown in table 4.3.3. It is therefore important to look briefly at different kinds of energy that a rotating fan transforms into as presented by the learners from both groups. Below are their excerpts:

Learner C12: heat energy, air energy, sound energy.
Learner C20: Potential, kinetic, and sound energy.
Learner E5: It transforms from electrical to kinetic to sound energy.
Learners E18: mechanical energy to kinetic energy to sound energy and wind energy.

Their responses show evidence that these learners acquired knowledge about energy sources and flow. Also, the use of pictorial representations in the conception of energy flow in this study has proved a better means of helping to understand energy flow. Although from the physicists' point of view, it was argued that the use of a materialistic view in explaining energy concept makes energy have objective existence which is inadequate for further learning of abstract quantities of energy (Warren, 2007), hence, Chen, Eisenkraft, Fortus, Krajcik, Neumann, Nordine, and Scheff, (n.d.) suggest that energy flow being conceptualised as something flowing from one system to another, this flow is analogue to say water flow. Hence learners who think about energy in terms of indestructible substances have gained a sound basis for understanding the conservation of energy.

Exposing learners to the dialogical argumentation instruction method gave more scientific reasons to explain the objective existence of energy, its ideas (observable and non-observable entity) as it became applicable to the conservation of energy, and learners expressed their thoughts, unlike the controlled group learners who were exposed to the traditional teaching method. Those learners who took part in argumentation activities showed evidence of having made significant conceptual gains concerning their responses on energy flow.

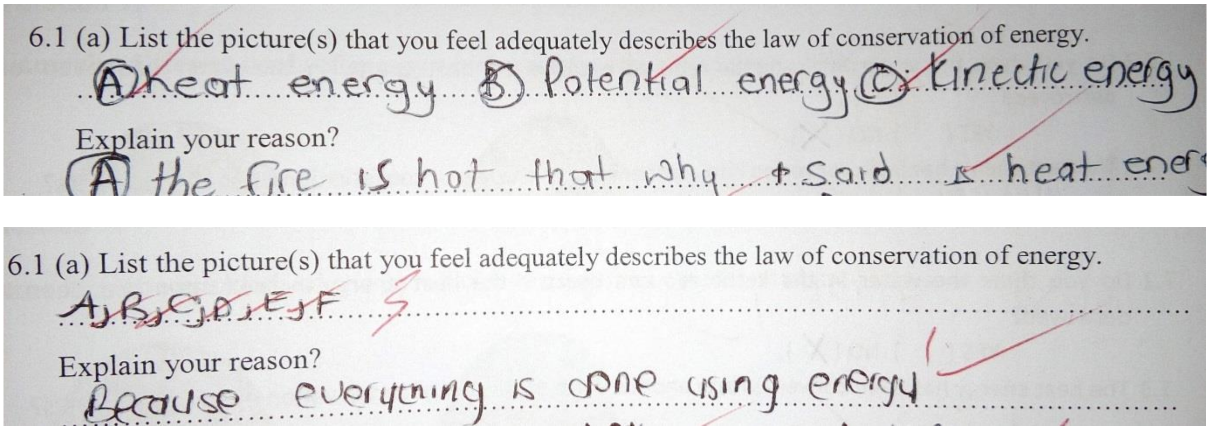
4.3.4. Diagrammatic representation of energy transfer (post-test).

In this category, learners' conceptions and application of energy transfer were elicited using diagrams to present their ideas and thoughts. Their representations were reviewed after the intervention. Table 4.3.4 below presents the learners' responses on the correctness of each statement, after been exposed to a teaching method.

Table 4.3.4: Diagrammatic representation of energy transfer (post-test)

ITEMS	THEME	CONTROL GROUP (POST-TEST)		EXPERIMENTAL GROUP (POST-TEST)	
		TALLY	SUB-TOTAL	TALLY	SUB-TOTAL
Q .6.1.	Correct identification with correct scientific reasons.	///// ////	9	///// ///// ///// /	16
	Correct identification with non-scientific/ literal reasons.	///// ////	9	///// ///	8
	Incorrect identification and non-scientific reasons	///// /	6	-	-
Q. 7.1	Correct scientific reasons.	///// /////	10	///// ///// /	15
	Non-scientific/ literal reasons.	////	4	///// ///	9
	Incorrect response	///// ////	9	/////	5
	No response	/	1	-	-
Q 8.1	The correct description of energy flow	///// /	6	///// ///// //	12
	Partial description	////	4	///// /	6
	Incorrect description	///// ///// ////	14	///// /	6
Q. 10	Clear illustration	///// ///// ////	14	///// ///// ///// ///// //	22
	In descriptive	///// ///	8	-	-
	Partial illustration	//	2	//	2

Question 6 presented learners with pictures that described various forms of energy. They were asked to carefully observe the pictures and list the picture(s) that they feel adequately described the law of conservation of energy and give their reasons. It was noted that 16 learners from the experimental group identified the correct pictures and were able to give scientific reasons for the selected pictures whereas 9 learners from the control group gave correct identification with the scientific meaning of those same pictures. The percentage increase after the intervention in the experimental group was 66 percent and 37 percent in the control group. Figure 7 shows excerpts of the experimental group learners' ability to identify instances of the law of conservation of energy from the pictures at the post-test:


6.1 (a) List the picture(s) that you feel adequately describes the law of conservation of energy.

(A) heat energy (B) Potential energy (C) kinectic energy

Explain your reason?

(A) the fire is hot that why I said heat ener

6.1 (a) List the picture(s) that you feel adequately describes the law of conservation of energy.

A, B, C, D, E, F

Explain your reason?

Because everything is done using energy

Figure 7. Learners' ability to identify instances of the law of conservation of energy from the pictures at the post-test.

It could be noted from the excerpts that at the post-test level, the learners did not only identify the pictures with mere 'alphabets' but also stated the type of energy that existed in the pictures they were presented with and backed up their claims. These findings may help us to understand that dialogical argumentation skills performed in this study empower learners to become good thinkers, even when they present their claims, they tend to defend them by providing evidence through writing irrespective of language barriers. Rivard and Straw (2000) acknowledged that discussion combined with writing enhances the retention of science learning for a long time.

Briker and Bell (2009) suggest that the goal of science education must not only emphasize mastery of scientific concepts but also learning how to engage in scientific discourse and the skill that is needed to partake in it (Kuhn, 2010). Erduran et al. (2004) contend that lessons involving argument for example conservation of energy would engage learners to externalize their thoughts during collaborative learning and beyond.

In question 10, learners were asked to draw a diagram that shows how energy is transformed from one form to another. A range of expression was elicited from their diagrams. More than two-thirds of the learners from each group, with their diagrams, gave a clear illustration of how energy could be transformed from one form to another. The number of learners who drew with a partial illustration and those with in-descriptive diagrams decreased. Although, there was a fifty-five percent increase among the experimental group in terms of presenting clear illustrative diagrams and an eight percent increase among the controlled group. It was noted from table 4.3.4 above that 14 learners from the controlled group expressed themselves correctly, whereas a total of 22 learners from the experimental group gave a clear description of energy transfer in their diagrams at post-test, after being exposed to the dialogical argumentation instructional model. Figure 8, shows excerpts of learners from the experimental group's diagrammatic representation of energy transfer:

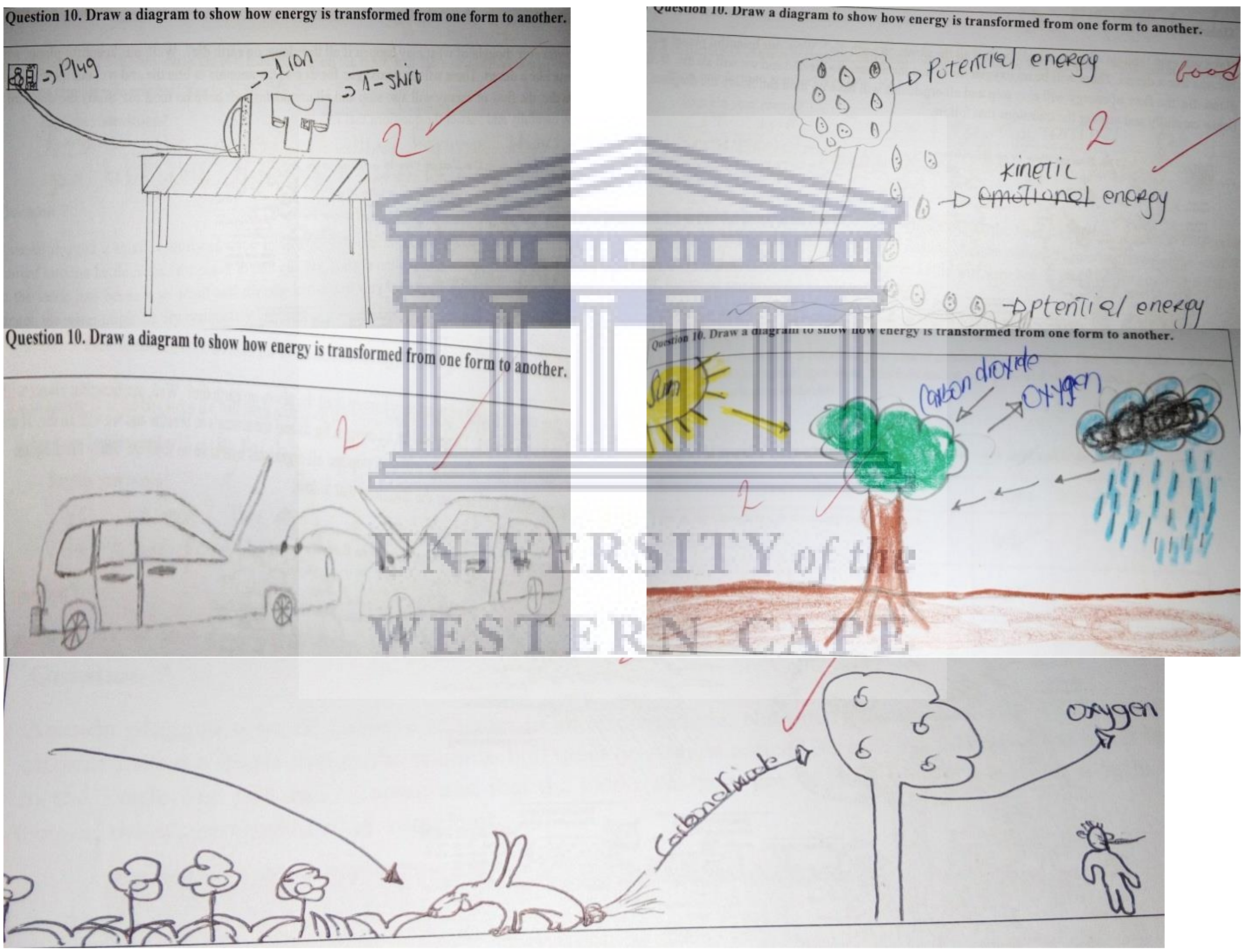


Figure 8. Learners' diagrammatic representation of energy transfer at post-test

Examination of learners' diagrammatic representation of energy transfer in figure 8, shows how they have improved their thoughts about energy transfer. Each of the diagrams gave a clear representation and an open-ended expression on how different forms of energy are transferred from one form to another e.g., diagram 1, gave an expression of energy in a thermal system where the source of heat from electrical energy is transferred into an electric iron (ironing a cloth) which gives off heat and the effect of the heat transfer could be felt in form of evaporation as the change in the cloth and temperature increase. Diagram 2: potential (energy in position) →→kinetic (energy in motion) ➝→potential (energy in position). The learners applied their knowledge of potential and kinetic energy to express the transfer of energy and the changes that were observed in the system e.tc.

These images emanated from the subconscious minds of the learners. They expressed their thoughts from within about energy transfer through drawing which aroused the belief that they understood the concept. The combination of findings in this section provides some support for the conceptual premise that the abstract concept of energy and conservation of energy exist within the thoughts of the learners and the application of DAIM enhanced the conception. Although extensive research has been carried out on energy and conservation, no single study exists which adequately expresses learners' conceptions of these abstract phenomena (energy) using diagrammatic representation. Köse (2008) in his research on photosynthesis indicated that drawings were often an under-utilized research tool in primary classrooms. He further contends that drawings provide valuable information in an open-ended means for creative expression that is difficult to achieve with other assessment strategies.

As a result of learners' exposure to DAIM, CAT described this kind of conception that happens within the learners' minds as "Suppressed", a point when valid, predictive, empirically testable evidence, or established social norms overlap and subdue the existing dominant belief.

4.3.5 Learners' post conceptions on 'energy as not created or destroyed'.

Several studies have revealed that among the four aspects of energy, energy conservation had been the most difficult concept to understand, and learners express limited information about the concept (Dalaklioğlu & Şekercioğlu, 2015; Herrmann-Abell & DeBoer, 2011; Opitz et al., 2014; Takaoğlu, 2018; Tatar & Oktay, 2007). In as much as learners find it easy to state and recite the definition, Chabalengula and Mumba (2012) argued that even though these learners can correctly state the energy conservation principle, they do not understand it fully including how it is applied in real life situations. After considering the misconceptions presented at the pre-test and for learners to understand the concept, this study set out to employ argumentation. As earlier indicated Lee and Liu (2010) suggest that understanding energy conservation fully requires the integration of many other ideas.

It will be of good interest to inform the reader, that during the intervention (implementation of DAIM) many ideas were integrated to enable learners to understand the abstract concept of conservation of energy. One of the major considerations and insights found amidst their misconceptions was the use of language, which lead to finding out from learners' point of view this very vital statement "energy as not created or destroyed". As I mentioned earlier in the literature review, it is the unfamiliarity of meaning in a language that results in the use of traditional teaching methods which often erupts into rote learning, reiteration, memorization, and recall (Webb, 2017), as Chabalengula and Mumba (2012) mentioned, this can cripple proper understanding of the concept. Even earlier before this generation, Burner (1978) contends that Language is important for the increased ability to deal with abstract concepts. He further argues that: "language codes stimuli and frees an individual from the constraint of dealing only with appearances but also provides a more complex yet flexible cognition" (p. 33).

After a lengthy dialogue in resolving the conceptual conflicts, particularly on the aspect stating that 'energy cannot be created nor destroyed…". Afterward Table 4.3.5 below provided us with learners' post conceptions of energy as neither created nor destroyed at the post-test:

Table 4.3.5: Learners' post conceptions on 'energy as neither created nor destroyed'.

ITEMS	THEME	CONTROL GROUP (POST-TEST)		EXPERIMENTAL GROUP(POST-TEST)	
		TALLY	SUB-TOTAL	TALLY	SUB-TOTAL
Q 1.5	Energy can be destroyed/created and lost	///// ////	9	/	1
	Energy cannot be created/ can be transformed	///// ///// /////	15	///// ///// ///// ///// ///	23
Q 7.3	Correct identification with correct scientific reasons.	///// ///// ///	13	///// ///// /////	15
	Correct identification with non-scientific/ literal reasons.	/	1	////	4
	Incorrect response	///// ////	9	/////	5
	No response	/	1	-	-
Q. 8.4	Energy was transformed	///// ///	8	///// ///// ///// ////	19
	The energy was destroyed and decay/rotten	////	4	/	1
	Energy will stop/disappear	/////	5	-	-
	Energy would remain the same	/	1	//	2
	No response	///// /	6	//	2

In question 1.5, the number of learners with misconceptions reduced. As shown in Table 4.3.5 above, about nine learners from the controlled group still maintained their belief that energy can be created and can be destroyed whereas only one learner from the experimental group had the view that energy can be created and destroyed. It was not sure whether this indicated a lack of understanding of the energy conservation or that the learner decided not to change his/her perception. For example, the response from the learner in the experimental group stated as follows:

> **Learner E7:** my reason is that if you had energy at that time by the other time you don't have it.

This response is likely from a learner who understood the scientific view but decided not to let go of his/her thought due to his preconception that he ran out of energy, probably after eating, playing, or doing some work. This was probably the reason most learners perceive energy as food. CAT described this notion as exhibited by the learner as "Assimilated" which is when a weak idea suddenly empowers a stronger one due to the persuasiveness or adaptability of the dominant idea in a given context. As earlier indicated Ogunniyi (2009) content that with DAIM any consensus reached should not be at the expense of changing or replacing (subdue or subsume) learners' beliefs with the scientific belief; rather learners should be made aware of the various worldviews on which a particular claim or argument may or may not be appropriate.

On the contrarily, it was found that out of 24 participants from the experimental group, 23 of them changed their perceptions and claimed that 'energy cannot be created or destroyed. These show a conceptual shift from their earlier views about the concept. This was a 95 percent response at the post-test and a 25 percent response at the pre-test. While 16 learners out of the 24 participants from the control group, changed their views, they believed energy cannot be created or destroyed. Therefore, the percentage increase in the experimental group was about 50 percent at the post-test and a 29 percent increase in the control group at post-test. Responses from learners who claimed that energy cannot be created or destroyed, from both groups were presented as follows:

> **Learner E 9:** Yes, energy cannot be created or destroyed. My reason is that we can't see or touch energy so we can't destroy energy, it transforms e.g., when you switch on phone it comes with light energy.
>
> **Learner E15**: Yes, energy cannot be created or destroyed because we cannot touch or see energy.
>
> **Learner C19**: Energy cannot be destroyed because it is a natural thing, and we cannot see it.
>
> **Learner C24:** My reason is that energy cannot be destroyed because it helps us to live healthy and even other things, energy is a natural thing that cannot be destroyed.

The most interesting part was that 95% of the students in the intervention group abandoned their initial perceptions and conceptions. Considering their responses, it was noted that this group of learners (experimental group) express their views with scientific evidence. For example, Learner E9 indicated his/her reasons and further backed it up with concrete evidence. These recent findings proved that argumentation played a vital role in the co-construction of a more meaningful understanding of the concepts discussed in class among learners. Kuhn (2010) suggests that collective learning empowers learners to become active thinkers and provides space to better understand scientific phenomena. Ogunniyi (2018) indicates that science tells the truth about nature and truth itself is a metaphysical term that connotes absolute understanding.

Another important finding was noted in Question 8.4 (see, table 4.3.5) where learners were asked, “in case a cat dies, what do they think will happen to the energy in its body? This item aimed to find out the consistency in connecting their understanding of energy conservation to a real-life scenario. At post-test, about 19 learners from the experimental group responded correctly with a scientific view that energy in the dead cat will be transformed. Two learners from the same group indicated that the energy would remain the same. The perception that energy would remain the same was not objected because it could be possible that the energy was in position (i.e., potential energy). The skills in this study show that a dialogical discussion provides learners with argumentative moves in taking a position on an issue, in such that only when one internalizes the existence of the phenomena they presented and reason about it in line with experience that one could find evidence which makes it a truth. Hoover (1996) suggests that learners come to learning situations with knowledge gained from previous experience and that prior knowledge influences what new or modified knowledge they will construct from new learning experiences.

On the other hand, eight learners from the control group indicated that energy in the cat’s body would be transformed and only a learner said the energy would remain the same. The percentage increase for the control group was at 16 percent and the experimental group improved at 46 percent.

Although, nine learners from the control group and one learner from the experimental group still maintain their prior non-scientific viewpoint which suggests that energy can be destroyed, created, stopped, or disappear, or even get lost. The remaining six learners from the control group and two learners from the experimental group could not respond to the question. What I am not clear about is whether the learners who did not respond to the question did not follow the instructions, or whether it indicated a lack of understanding of the conservation of energy concept. However, the consistent findings in this study show evidence that the majority of learners have changed their view to more scientific views, and implementation of DAIM in this study has enhanced learners' understanding of conservation of energy.

4.3.6 Learners' post-test ideas about conservation of energy

This study sets out with the aim of assessing the effectiveness of DAIM in enhancing learners' conceptions of conservation of energy. Learners' post conceptions of conservation of energy were collected using the Ideas about Conservation of Energy Questionnaire (ICEQ). The learners were introduced to scientific knowledge about energy conservation during the intervention. After this, the learners were requested to respond to each question based on the alternative options provided for them, to decide whether they agreed, disagreed, or do not have an idea about the question. Their responses were gathered after they had been exposed to DAIM (experimental group) and the traditional teaching method (controlled group). For easy analysis, each question was categorised into themes. The results from the control group and the experimental group were further compared in response to research question two. The findings were presented in table 4.3.6 below:

Table 4.3.6: Themes derived from the learners' post conceptions of sources, energy transfer, and conservation of energy.

Themes	Items	Groups	Agreed (%)	Disagreed (%)	Don't Know (%)
Sources and Forms of Energy	1, 9, 10, 11, 12	**E**	68.3	15.8	15.8
		C	50.0	29.4	16.6
Energy transfer	2, 3, 4, 8	**E**	78.1	16.6	78.1
		C	55.2	34.4	10.4
Conservation of energy	5, 6, 7, 13, 14	**E**	48.4	25.8	25.8
		C	45	34.2	20.8

Note: C = Control group; E = Experimental group.

Learners' post conceptions on sources and forms of energy (Items 1, 9,10 & 11).

This section of the questionnaire requires learners to agree or disagree with the information listed in each item of the questionnaire. However, as shown in table 4.3.6, about 68.3% of the learners from the experimental group agreed positively with the scientific information that expresses sources of energy as the starting point of an energy system. 50% of the learners from the controlled group agreed with the information. Although more than half of the learners in both groups showed a sound understanding of the concept, it was noted that the experimental group improved by an 18.3% increase when compared with the control group at post-test. The learners from both groups agreed to the following statements:

> "We get all our energy from renewable and non-renewable sources".
>
> "Heat energy is one of the important forms of energy we come in contact with every day".
>
> "Energy is stored in many stationary objects".
>
> "The energy in motion is called kinetic energy".

Though 15.8% and 29.4% of the learners from the experimental and the control group respectively disagreed with the information on the above-mentioned statements, about 15.8% of the learners from the experimental group and 16.6% from the controlled group indicated that they had no idea about the information. It could be that these learners did not pay much attention to the question and probably were guessing what they thought were the correct answers just for them to finish fast with the questions.

Learners' post conceptions on energy transfer (Items 2, 3, 4, & 8).

In questions that deal with energy transfer, about 78.1% and 55.2% of learners from the experimental and the control group respectively showed a sound understanding of the concept by giving an appropriate response. They agreed to the following statements:

> "Energy from the sun causes water to be converted (jika/guqulela) into rain through vapour".
>
> "When you switch on a fan in your bedroom, the electrical energy gets converted into mechanical energy which causes the fan to rotate".
>
> "Energy is converted from the food we eat to enable us to do various activities e.g., run, jump and so on".
>
> "The radio transmits electrical energy into sound energy".

Although two-third of the learners from both groups responded correctly to the above statements that expressed energy transfer, it is evident that the learners in the experimental group performed better than those in the control group with a 23.1% difference. However, 16.7% and 34.4% of learners from the experimental and the control group respectively disagreed with the questions while 5.2% and 10.4% indicated uncertainty (don't know) to the questions.

Learners' post conceptions on conservation of energy (Items 5, 6, 7, 13 & 14).

The percentage of learners' agreement in relation to scientific information on conservation of energy declined. Surprisingly, about 49.4% of the learners from the experimental and 45% from the control group demonstrated a proper understanding of the questions with a scientific response on the conservation of energy. They agreed to the following statements:

> "Energy is converted from one form to another therefore it cannot be created or destroyed".
>
> "the law of conservation of energy can be confirmed by experiment."
>
> "Energy cannot be destroyed but it can be wasted".

Contrary to expectations, the performance in both groups was not impressive as compared to other aspects of energy presented in the questionnaire. Although there is evidence that the experimental group outperformed the controlled group, it is not sure whether the learners (Especially the experimental group) paid full attention to the questions in the questionnaire. However, 25.8% and 34.2% of learners from the experimental and the control groups respectively demonstrated no understanding of the concepts and thereby disagreed with the information on conservation of energy. However, 25.8% and 20.8% from experimental and control respectively indicated that they don't know about the information.

There are several possible explanations for this section of the result. First, it seems possible that these results are due to indecisiveness to make the right choice as some of the learners rush to finish fast and go home, or that the questions were not clear to them. Another possible explanation has to do with learners' notions which CAT described as "equipollent". This happens when two rival ideas tend to co-exist without any existing conflict in the mind. Therefore, they choose to battle with uncertainty. However, previous studies have reported that learners' understanding of different aspects of energy were found to progress in sequences such as energy forms and sources, energy transfer, energy degradation, and energy conservation (Herrmann-Abell et al., 2011; Neumann et al., 2013; Nordine, 2016; Opitz et al., 2015; Opitz et al., 2017; Park & Liu, 2016). More so, the lowest achieved scores across all grades were found in the aspect of conservation of energy. However, the general post-test results have shown that DAIM enhanced learners' (experimental group) understanding of conservation of energy compared to their counterparts in the control group; it also improved their scientific conceptions of conservation of energy.

4.4. Are the learners' conceptions of conservation of energy related to their age, gender, or language?

This section attempts to report on whether the learners' conceptions were influenced either by their age, gender, or language. The report from their conceptions was assessed based on their performance by using the Science Achievement Test (SAT). The Cloze Test (CT) was utilised to assess their understanding of the concept in relation to language; since only Xhosa speakers participated in the study. An independent sample t-test was conducted to compare the learners' performance concerning their age, gender, and language. This was compared independently on the experimental group and the control group using the post-test scores. The act of gathering statistical information on the performance of learners during teaching and learning was of great importance in the practice. Apparently, several findings have affirmed that learners' performance in relation to these three aspects (age, gender, and language) plays a distinct role in learning in accordance with the instructional strategies. The following sub-sections analyse each of the aspects.

4.4.1 The learners' conceptions of conservation of energy in relation to age

Age had been a vital issue within the educational system, although findings from researchers tend to vary. An examination of learners' performance on account of their age is as shown according to the experimental group (E) and the control groups (C) together in Table 4.4.1 below:

Table 4.4.1: Performance of learners based on age.

Groups	Age (yrs.)	N	Mean	SD	SEM	Df	T- critical	T-value	2-tailed test
E	11	1	27.00	-	-				
	12	9	34.22	8.243	2.748	8	2.30	0.856	0.417
	13	11	34.91	8.166	2.462	10	2.22		
	14	3	29.00	4.583	-	-			
C	11	1	34.00	-	-	-	-		
	12	6	31.00	6.663	2.720	5	2.57	4.613	0.006
	13	16	23.50	8.438	2.110	15	2.15		
	14	1	17.00	-	-	-	-		

Note: C = Control group; E = Experimental group. Alpha=0.05

Table 4.4.1 above shows that the participated grade seven learners from the two groups were under the age group of 11 to 14 years old. Due to variation in the number (N) between the age groups of 12, 13, and 14years olds, only the 12-year-olds, and 13year olds were sampled using the paired sample t-test. The 11year old in the experimental group was not computed because the number (N) is less than or equal to one as appeared in Table 4.4.1. The experimental group results show that there was no significant difference in scores between the 12year olds (younger learners) and the 13year olds (older learners). The 12year olds had a Mean score of 34.22 and the 13year olds with a Mean score of 34.91. This shows a mean difference of 0.69 which was very small. The t-critical value for 12year old and 13year old was found to be 2.30 and 2.22, respectively. The calculated t-value of 0.856 was less than the critical values [i.e., t-val. (0.85) < tcrit. (2.30)] and [t-val. (0.85) < t-crit (2.22); p=0.417]. Therefore, the null hypothesis was not rejected. This shows there was no difference in conceptions of conservation of energy between the two age groups from the experimental group. This finding agrees with Imlach's (2017) recent research findings which showed that age did not influence learning and understanding of science concepts. Clark et al. (2015) suggested that the ability to acquire knowledge is largely unaffected by cognitive age.

Of the four age groups in the control group, there were only one 11 years old and one 14-year-old learner; as such, they were considered accidental because the number (N) is less than or equal to one as appeared in table 4.4.1. However, learners in age groups 12 and 13year olds were sampled.

The t critical value for the 12 year and 13year olds was found to be 2.57 and 2.15, respectively. The 12year olds mean score was significantly higher at 31.00 as compared to the 13year olds mean score of 23.50, with a mean difference of 7.50. The t-test value gave a significance at t = 4.613; p = 0.006. In other words, the t-value of 4.613 is greater than the critical values (t=4.613 > t crit. =2.30) and t-4.613 > t-crit. =2.22; p=0.006). Therefore, the null hypothesis was rejected. The 12year olds (younger learners) performed higher than the 13year olds (older learners) among the control group. This finding was similar to Momanyi et al (2015) research that investigated the learners' age in relation to their academic performance and their findings significantly indicated that the youngest learners outperformed their older classmates.

Although, findings have shown that experimental group conceptions did not influence their age. It is, therefore, evident that DAIM bridged the gap on their conceptual differences based on their age since several researchers reported findings on how certain age group attains significantly higher when compared to relative age counterparts, which was the same with findings from the control group learners, where 12year olds (younger) outperformed and understood better than the 13year olds (older learners). This could be an indication that teaching without explicit instruction (traditional teaching method) could contribute to disparities among learners. Darling-Hammond et al. (2020) suggest that teaching should foster conceptual understanding, engagement, and motivation by designing relevant, problem-oriented activities that incorporate explicit instruction on key ideas. Therefore, DAIM contribution to the E-group improved their conceptions as it actively engaged all the learners into scientific dialogical learning.

4.4.2. The learners' conceptions of conservation of energy in relation to gender

The analysis in Table 4.4.2 provides the answer to this question. An examination of learners' performance based on gender is as shown according to the experimental group (E) and the control groups (C) together in Table 4.4.2 below:

Table 4.4.2: Performance of learners based on gender at post-test.

Groups	Gender	N	Mean	SD	SEM	Df	T-critical	T-value	2-tailed
E	Boys	7	31.00	9.933	3.754	6	2.44	0.75	0.48
	Girls	17	33.94	8.257	2.003	16	2.12		
C	Boys	9	20.67	6.083	2.028	8	2.26	3.06	.015
	Girls	15	28.47	8.626	2.227	14	2.14		

Note: C = Control group; E = Experimental group. Alpha at 0.05

Table 4.4.2 shows that among the experimental group, the mean score for boys (M = 31.00, SD = 9.933) and the mean score for girls (M = 33.94, SD = 8.257) with a mean difference of 2.94 were very small. The calculated t-value is 0.75 while its corresponding t-critical is 2.44 at 0.05 alpha level. The calculated t-value is less than the critical value. This implies that there is no significant difference in the boys' and girls' conceptions of conservation of energy. This means that among the experimental group, gender does not have any significant effect on the conceptions of the scientific concept.

The findings show that boys and girls have a similar understanding of conservation of energy among the experimental group. The finding was consistent with that of Angaama (2012) who implemented DAIM in his study found no significant difference between male and female learners concerning the conceptual understanding of the scientific concept on sound. The finding also agrees with Udousoro's (2011) study who indicated that gender does not have any significant effect on the academic performance of students in science. Patrick et al. (2009) suggested that early meaningful teaching, motivation, and participation of boys and girls in science learning promote their interest in science.

The similarities in scores may be attributed to their level of involvement in the construction of knowledge and reasoning during a dialogical scientific discussion (DAIM). Also, contributes to their positive changes in their attitude to science.

From Table 4.4.2, boys in the control group have a mean of (M=20.67, SD = 6.083) and the mean for the girls (M = 28.47, SD = 8.626), with a mean difference of 8.20, which is high. This indicates a significant difference among the gender in the control group, as the calculated t-value of 3.06 is greater than the t-critical value of 2.26 at 0.05 alpha level. This implies that there is a significant difference between the boys' and the girls' understanding of conservation of energy. This means that the girls in the control group seemed to have better conceptions of scientific concepts than the boys in the control group.

Ghazvini and Khajehpour (2011) suggested that differences exist in the cognitive-motivational functioning of boys and girls in the academic environment, with the girls have a more adaptive approach to learning tasks.

4.4.3 The learners' conceptions of conservation of energy in relation to language

Language is not simply a collocation of words and sentences, but words and statements impregnated with specified meanings within a given context (Ogunniyi, 1999), hence the use of the cloze test in the analyses of this section. An individual's ability to read, write, assimilate, explain, discuss, or express a point of view about conservation of energy to a large extent, depends on familiarity and conceptual understanding of the words from the language of his/her communication.

However, the participants surprisingly happened to be only Xhosa speakers and the English language was used in their schools as a medium of instruction among the two groups. Therefore, a cloze test was used to assess their use of (scientific words) language in the understanding of the concept. A simple paired t-test statistical analysis was carried out to compare the two groups in terms of their performance regarding language. Overall, language did not affect the experimental group and the control groups differently in these measures as shown in table 4.4.3.1 below:

Table 4.4.3: Learners' conceptions of conservation of energy in relation to language at post-test stage

	Groups	Mean	N	Std. Dev.	t-value	df	t-critical	Sig. (2-tailed)
Paired	Post-test Control	5.83	24	4.26	0.551	23	2.06	0.58
	Post-tests Experimental	6.54	24	5.19				

The two groups' performance in this very test was poor, (t-value=0.55 at sig. 0.58; $p<0.05$). There were no significant differences between the two groups. The experimental group had a mean score of (M= 6.54) and a standard deviation of (Std. Dev. = 5.19) which the difference was very small compared to the control group with a mean score of (M=5.83 and Std. Dev. = 4.26). The t-critical (2.06) > t-value (0.55), the null hypothesis was not rejected. There is no difference between the means. However, the learners' understanding of conservation of energy seems not to be about their language rather their perception of the phenomena could be a result of individuals' daily experiences and observations since it is a natural phenomenon. Osborne et al. (2001) suggested that language does not matter in science but what matters is what we do with the language. This proposes the relevance of the language towards understanding a concept and in as much as to avoid using language to bring in meanings that might contradict the scientific phenomena.

4.5 Learners' attitude towards science

According to Osborne, Simon & Collins, (2010), learners' attitude is inherent to their involvement in science learning and should be invaluable in their measurement. Ogunniyi (1996) made it clear that the mutual distrust that learners exhibit towards science is related to how human knowledge is presented. Therefore, the way a scientific concept is taught can enhance or hamper learners' attitudes towards science. Their attitude to science was gathered before and after the intervention using the Individual Attitude towards Science Questionnaire (IASQ) instrument. Their responses to IASQ were further grouped into themes; Self-concept (i.e., academic achievement and teacher-reported improvement in science); Intrinsic value (i.e.. the gratification and interest that a learner gains from a scientific activity); and Utility value (i.e., considered the usefulness of science for the future goal).

Self-concept were made from items 4,7,10,11, & 13; Intrinsic value: 1,3,5,6,8,12,16 & 17, and Utility value: 2, 9, 14, 15, & 18. Findings on learners' attitude were presented in Table 4.5.1 below:

Table 4.5: Attitudes of grade seven learners to science

Themes	Groups	PRE-TEST (%)			POST-TEST (%)		
		A	**D**	**DK**	**A**	**D**	**DK**
Self- concept	E	58	39	3	55.7	40.8	3.3
	C	49.5	32.3	18.2	52.6	33.3	14.1
Intrinsic value	E	85	10.8	4.2	89.2	10.8	-
	C	42.5	39.2	18.3	59.2	30.8	10
Utility value	E	54.2	37.5	8.3	64.2	27.5	8.3
	C	40.8	36.7	22.5	50	37.5	12.5

Note: C = Control group; E = Experimental group.

4.5.1. Self-concept.

Table 4.5. shows that more than half of the learners in both groups exhibited a positive attitude towards science at the pre-test and the post-test. It would be clear to note that some disagreements in certain questions indicated a strong positive attitude to science (see table 4.5.1 below). However, considering the learners' attitude related to values to science (Self-concept), their responses showed active participation in acquiring better academic achievement as they receive feedback from their teachers' reports in science. Mitevski, Popeska, and Petrusheva (2020) affirmed that self-concept is a powerful predictor of achievement. Learners receive motivation to fulfill their self-concept in science. See excerpts below:

> **Learner E19:** When I don't understand a scientific idea, I quickly ask my teacher, parents, or friends to help me.
>
> **Learner C11**: My science teacher encourages me to learn science.
>
> **Learner E5:** I feel so happy when my teacher accepts my contribution to the science class.

These responses show that the teacher plays a vital role in moderating learners' interest in science and teaching. According to Ibrahim (2014, p.2) learners' perception of teachers' classroom effectiveness contributes positively to their self-concept and the kind of perception a learner has about his teacher tends to influence his self-concept towards this teacher and the subject(s) he teaches.

4.5.2. Intrinsic Value

An examination of Table 4.5 also showed a positive science related intrinsic value, among the two groups, although a higher percentage was expressed in the experimental group at 85% (pre-test) and 89.2% during the post-test. Intrinsic value attributes the gratification and interest that a learner gains from scientific activity. See the excerpts below:

> **Learner E1:** I have an interest to know new inventions in science.
>
> **Learner C12:** I don't give up easily, no matter how difficult a scientific idea is.
>
> **Learner E7:** I like to study science because we are allowed to perform experiments and discuss interesting subjects.
>
> **Learner C20:** I like to watch science movies.
>
> **Learner E16:** I like science because it is a practical subject.

These responses show that some learners' positive attitude to science goes beyond what they have been taught in the classroom. They directly or indirectly express their interest in science with related scientific activities they come across. According to Schwartz (2020), he suggested that intrinsic value is a true belief of knowledge that is valued for its own sake, and such acts of valuation help to explain the overall scientific worldview.

4.5.3 Utility Value

Considering the learners' utility value, Table 4.5 shows that almost half of the learners from both groups indicated positive utility at the pre-test, and more than half showed expressed positive utility value at post-test. Their attitude to science was positively expressed towards their future goal in learning science. The learners' excerpts are presented below:

Learner E2: I want to become a scientist in the future.

Learner C4: I like to study science because it explains how things work.

Learner E6: I have the ability to do science.

Learner C20: I like to repair things when they stop working.

The learners' responses above show that their attitude to science was shaped by the inspiration they had for the future. Sheldrake, Mujtaba, and Reiss (2017) suggested that to increase the numbers of learners aspiring towards science careers, educators could instead attempt to foster learners' attitudes, such as their perceived utility of science, and/or apply various teaching and learning approaches or activities to inspire or engage learners.

Although about half of the learners at the pre-test showed a positive attitude towards science, it was revealed that the use of DAIM in this study also seems to have increased and improved the learners' attitude towards science among the experimental group (see table 4.5 above).

Table 4.5.1: Learners' attitude towards science

	STATEMENTS	Experimental Group Pre-test			Experimental Group Post-test			Control Group Pre-Test			Control Group Post- Test		
		A	**D**	**D/K**	**A**	**D**	**D/K**	**A**	**D**	**D/K**	**A**	**D**	**D/K**
1.	I have interest to know new inventions in science	20	2	2	22	-	2	15	6	3	15	7	2
2.	Science is a difficult subject; no matter the effort I put into it I don't feel hopeful to understand science.	8	14	2	3	20	1	13	7	4	10	8	6
3.	I don't give up easily, no matter how difficult a scientific idea is.	17	5	2	20	3	1	18	2	4	19	1	4
4.	When I don't understand a scientific idea, I quickly ask my teacher, parents, or friends to help me.	21	2	1	21	1	2	17	5	2	16	7	2
5.	I find science to be an enjoyable and easy subject.	19	4	1	23	1	-	7	12	5	10	10	4
6.	During the learning process, I find it easy to connect what I learn in science with what I do at home.	17	6	1	21	2	1	10	9	5	15	4	5
7.	I feel so happy when the teacher accepts my contribution to the science class	21	3	-	21	3	-	18	4	2	15	7	2
8.	I like to study science because we are allowed to perform experiments and discuss interesting subjects.	16	5	3	21	1	2	9	8	7	12	6	6
9.	I want to become a scientist in the future	10	12	2	17	5	2	6	11	7	14	9	1
10.	Although I do not really like science, my parents and teacher force me to learn it	5	17	2	2	22	-	5	12	7	9	15	
11.	I do not like science because of the way it is taught in class	4	20	-	3	21	-	11	11	2	7	16	1
12.	I enjoy science when the content is explained in my home language	22	2	-	16	7	1	12	10	2	18	6	-
13.	My science teacher encourages me to learn more science	18	5	1	20	2	2	13	5	6	13	6	5
14.	I like to repair things when they stop working.	14	5	5	15	5	4	5	10	9	12	7	5
15.	I don't think I have the ability to do science.	8	13	3	1	20	3	8	12	4	6	14	4
16	I like science because it is a practical subject	18	3	3	21	3	-	6	9	9	12	8	4
17	I like to watch science movies	14	7	3	16	8	-	13	9	2	14	9	1
18	I like to study science because it explains how things work	22	2		23	1		9	11	4	15	6	3

4.6 Interview

A semi-structured interview was conducted among the group representatives from the experimental group. The purpose of choosing the leaders was to save time. They were interrogated based on how DAIM impacted their understanding of the concept and what they have ideally learnt throughout the lesson sections. The interview provided the opportunity for the interchange of views on a topic of mutual interest and to find out if it impacted them positively or not. Cohen, Manion, and Morrison (2007) agreed that group interview detects how learners support, influence, complement, agree and disagree with each other, based on their knowledge about the subject content**.** The need for an interview was stated by Kvale, (1996) as the centrality of human interactions for knowledge production and emphasizes the social situatedness of research data. Hence the five group leaders responded to the questions as stated below;

Question 1. What about the argumentation lesson did you like the most?

This question investigated the aspect of dialogical discussions that made a positive impact on the learners' understanding of the concept as well as their group. It was noted that the interviewees commented on a different aspect of energy. This I could say, emanated from the previous conceptions they had about energy which was dominant in their minds. Some of such conceptions include describing energy as food, strength, power, etc. However, their reactions and responses depicted some kind of satisfactory and clear understanding of the energy concept. For example; some of the learners used the word 'when' meaning 'at a time'. This is an indication that their previous knowledge about energy was faulty. Furthermore, DAIM enhanced their understanding of conservation of energy; their responses invariably covered every aspect of the topic starting from the concept of energy, sources of energy, energy transfer as well as conservation of energy. Below are their excerpts:

Group 1*: when talking about energy.*
Group 2: *We liked how energy is stored and how we use it.*
Group 3: *when we heard energy cannot be destroyed or created.*
Group 4: *I like the energy lesson and how Sipho was using energy.*
Group 5: *about the sources of energy.*

Question 2. Would you say this method of instruction is something different from the way you have been learning science before?

This was like a probing question to know if the learners observed the change in teaching method (DAIM) or otherwise. The extract/comment below shows that the learners were excited and influenced by the Dialogical argumentation instructional model (DAIM) method of teaching which indicated a high knowledge production among the learners. For example, one of the individuals stated as follows, ‘Yes it is something different because we have not learnt with argumentation before’ and another learner commented, ‘there is a difference because I don’t know science before and some of the sources of energy I did not know’. The above responses reveal the sincerity of individuals who were deprived of attention during teaching.

However, DAIM brought light to their understanding of science. Similarly, another learner indicated the use of movement energy instead of kinetic energy. This response conforms to Tatar & Oktay's (2007) view that preliminary explanations about a certain concept in our daily life provoke learners’ into alternative conceptions. However, not only that DAIM improved their understanding; the learners’ dominant belief was suppressed into valid, predictive, empirically testable evidence as stated by CAT. Below are their excerpts:

Group 1: Yes, it is something different because we did not know that movement energy is kinetic energy, we were used to movement energy.
Group 2: We learnt something very important.
Group 3: Yes, it is something different because we don’t learn with argumentation.
Group 4: There is a difference because I don’t know science before and some of the sources of energy, I did not know but now I like it.
Group 5: Yes, there is something different because even in my class I am good at science.

Question 4. What was most interesting to you about learning the conservation of energy?

This question points to the research topic, to find out the area learners understand most in the topic. The overall response to this question was very positive. It was noted that the majority of the participants emphasized their interest in the aspect of energy being transferred and cannot be created or destroyed. However, one of the learners acknowledged that they were eating and learning. That means hunger could be a depriving factor in teaching and learning. Below are their excerpts:

Group 1: when we were talking about where we got renewable and non-renewable sources of energy. Also, we were eating and learning.

Group 2: It is energy or sources of energy or forms of energy.

Group 3: It was interesting that energy can be transformed.

Group 4: It was on energy and conservation, that energy cannot be created or destroyed.

Group 5: It was interesting especially when I heard that energy cannot be created or destroyed it can only be transformed.

Question 6. Does brain-storming (self-argumentation) help you to think better now than before?

Brain-storming is one of the advantages of DIAM, it inculcates in learners the ability to think positively to solve a problem as well as to create new ideas. These most times happen among a group of people whereby one involves in a self-argumentation and figure out a solution to a problem. However, the learners affirm that brain-storming made them think well than before. They indicated with a 'Yes' meaning they were positively in agreement with the question. Below are their responses:

Group 1: Yes, a lot now

Group 2: Yes, it makes me think better than before.

Group 3: Yes

Group 4: Yes, the brainstorming helped me than before.

Group 5: Yes

Question 7. What do you think should be changed in the way you are taught science and other school subjects?

A small number of those interviewed suggested that Mathematics, Science, and other subjects should use the argumentation method to teach them. They responded as follows:

Group 1: I wish to learn this way in mathematics. When we are thought something, we should be thought in a good way and I understand it carefully.

Group 2: I like to change to be taught in English.

Group 3: I would like my school to teach with argumentation.

Group 4: what I would like to change is that they must teach us all the lessons in every subject with argumentation.

Group 5: I want to learn more about science.

Question 8. Has your experience in the argumentation lessons helped you to participate more actively in the science classroom or any other classroom than before?

In response to Question 8, most of those interviewed indicated with a 'Yes' which shows that they agreed with an idea that argumentation lessons helped them to participate more actively in the science classroom and other classrooms than before. Two participants further included that the teaching process made them like science more than before. Below are their responses:

Group 1: Yes, I like science too much now and I have learnt a lot now.
Group 2: Yes, it has been helped me.
Group 3: Yes, even at school I know the science.
Group 4: Yes, because first I don't like science but now, I like it. I have learnt more than I thought.
Group 5: Yes

Question 9. Is there anything else you would like to share?

This question further requested the learners' opinions and suggestions rather the interviewees kept on sharing their testimonies on ways at which DAIM enhanced their learning. For example, they answered as follows:

Group 1: *I would like to share that energy in position is potential energy. Everyone should know that even if you are sleeping you still have energy.*
Group 2: *No, I learnt a lot about science.*
Group 3: *Science is the most interesting subject.*
Group 4: *Yes, is that the law of conservation of energy has thought me that there are more sources of energy.*
Group 5: *No*

In general, the interviewees responded positively to the question which was a clear indication that DAIM enhanced their understanding of all that pertains to energy and conservation of energy. Also, it changed their alternative perception into scientific conceptions of the phenomenon.

4.7 Summary

This chapter described, analysed, and interpreted the results obtained from the Northern Primary school (Experimental group) and the Metro Primary school (controlled group) on their conceptions of conservation of energy among the grade seven learners. The findings were presented by answering the research questions based on the theoretical and conceptual frame outlined for the study. This chapter presented the demographic characteristics of the participants. The findings from the research instruments at the pre-test provided evidence that the two groups were statistically comparable at the beginning of the study.

In answering the research questions, the analysis did not only provide answers to the concept of conservation of energy but also explicitly addressed all the four aspects of energy that directly or indirectly hinder the proper conception and general learning expectations towards the concept of conservation of energy. It was noted that the learners from both groups had a common view about the conservation of energy.

After the intervention, this study revealed a significant cognitive shift in learners' understanding of the conservation of energy. An analysis of classroom observation of the experimental group showed that the learners constructed their knowledge during the DAIM-based classroom activities. This chapter also provided findings on the learners' conceptions of the concept with consideration to their age, gender, and language. Also, the learners' attitude to science was analysed. Further evidence that was collected from the interviews among learners in the experimental group indicated that they have learnt science better than before and suggested that the argumentation method should be used in teaching other subjects.

The next chapter shall further present the major findings, implications as well as limitations of the study.

CHAPTER FIVE

IMPLICATIONS, RECOMMENDATIONS, CONCLUSION

5.1. Introduction

Primary school science is the foundation to further studies in science and related fields. It is therefore, necessary to introduce learners to essential scientific concepts right from the start of their formal education. Today, we live in a world largely driven by science and technology and it is critical to expose learners to these important human enterprises early in life. Since scientific concepts are the building blocks of scientific principles and/or generalizations, it is important that learners develop valid understandings of these concepts to be successful in pursuing scientific careers. However, teachers have a critical role to play in introducing their learners to the basics of science in such a way that they develop an interest in the subject beyond the primary school level. Although the extant literature has revealed that learners generally encounter difficulty with abstract scientific concepts e.g., conservation of energy, the central focus of this study, the instructional approach that a teacher uses can make a difference. It was in light of this that this study examined the conceptions on conservation of energy among grade seven learners in two schools in Cape Town namely, Metro Primary School and Northern Primary School using argumentation instruction. Argumentation instruction has been found to be effective for enhancing learners' understanding of diverse scientific concepts (e.g., Erduran et al, 2004; Osborne, 2010; Simon & Johnson, 2008). More specifically, I chose an argumentation instructional strategy known as the Dialogical Argumentation Instructional Model (DAIM) not only because of its effectiveness in enhancing learners' conceptual understanding of science but also for enhancing their awareness of the scientific value in their indigenous knowledge (Diwu & Ogunniyi, 2012; Moyo & Kizito, 2014; Ogunniyi, 2007a & b; Ogunniyi & Hewson, 2008). A related aim of the study was to find out whether or not their conceptions of the conservation of energy were influenced by their age, gender, or language.

In the course of action, a pre-test was administered to the learners before the intervention and later a post-test was administered to them after the intervention. Both qualitative and quantitative data were collected, analysed, and discussed. This chapter summarises the major findings and implications for instructional practice and teacher education. It also suggests a few recommendations for future studies.

The major findings of the study for the research questions are presented in the section that follows.

5.2 Summary of major findings

Conceptions of conservation of energy among grade seven learners.

The difficulty that learners normally encounter with abstract concepts such as conservation of energy was confirmed in this study (Dalaklioğlu & Şekercioğlu, 2015; Govender, 2011; Herrmann-Abell & DeBoer, 2011; Takaoğlu, 2018). The results gathered from Metro Primary School (Control group) and Northern Primary School (Experimental group) at pre-test i.e., before the intervention, indicated that the grade seven learners involved in the study had certain scientific as well as alternative conceptions of the conservation of energy. Their alternative conceptions were not different from those that have been reported in earlier findings within the same locality. For example, the learners associated energy with food, power, muscle, strength, movement, etc. Furthermore, they encountered considerable difficulties in identifying different forms and sources of energy. Many of them believed that the energy used is lost, energy can be created and destroyed in one way or the other. These findings were similar to what other researchers in the field found (e.g., Dalaklioğlu & Şekercioğlu, 2015; Herrmann-Abell & DeBoer, 2011; Opitz et al., 2014, 2017; Oktay et al., 2007; Takaoğlu, 2018).

Effectiveness of DAIM in enhancing learners' conceptions of conservation of energy.

All the studies reviewed so far on learners' understanding of energy and its conservation have mostly focused on learners' misconceptions of the concepts. However, most of these studies have not gone further to determine what instructional strategy could be used to mitigate the negative impact of such alternative conceptions on learners' understanding, especially the abstract concepts. The capacity to gain an accurate and deep understanding of learners' views about the phenomena, made this study look into other possible related concepts that would have contributed to the misconceptions on conservation of energy. The findings were sequentially drawn from four aspects of energy; energy, sources/forms of energy, energy transfer/transformation, and conservation of energy. It was revealed that these related concepts tend to cause misconceptions among learners about the conservation of energy (Tatar & Oktay, 2007). It was for the same reason that I tried to determine the effectiveness or otherwise of DAIM in facilitating grade seven learners' understanding of the conservation of energy.

It was found that the intervention strategy namely, DAIM seemed to: captivate the interest of the learners; engage them with thought-provoking discussions about the concept (its applications in physical human activities and its abstract nature); arouse their interest in actively constructing their knowledge; assist them to present their facts boldly; and to read, write and present their arguments more confidently than was at the commencement of the study. Rivard and Straw (2000) acknowledged that discussion combined with writing enhances the retention of science learning for a long time. It was evident that during the process, most of the learners gradually developed a deeper understanding of the concept through frequent 'question and answer' sessions regardless of their age, gender, or language.

The findings revealed that DAIM enhanced the experimental groups' understanding of the concept more than the control group. A significant cognitive shift was noted with learners' scientific understanding of the conservation of energy. About eighty percent of the learners in the experimental group changed their previous misconceptions to more scientific conceptions unlike their counterparts (control group) who were taught with the traditional teaching method. Learners in the experimental group were able to understand that:

- We cannot see or touch energy, that energy is not an object.
- Energy is needed to make everything work, move, or live.
- A source of energy has energy stored waiting to be used.
- There are two types of sources of energy: (1) non-renewable sources of energy: this energy cannot be replaced once it is used; it transforms, e.g., fossil fuels (coal, oil, natural gas). (2) renewable sources of energy: they are continually refilled even after being transformed into other forms of energy e.g., hydro power, wind, sunlight, biofuel (wood).
- The law of conservation of energy states that energy cannot be created or destroyed but can only be transformed from one type of energy to another. This simply means that any energy

in use changes into another form when it is doing work, e.g., a car that uses fuel transforms its energy into mechanical energy, kinetic energy, heat energy, and sound energy.

The findings listed above suggest that DAIM is an effective instructional strategy for teaching abstract scientific concepts, in this case, the conservation of energy was well understood by the learners. This is probably because it creates the necessary avenue for learners to construct a meaningful understanding of the concepts during the discussion. This finding corroborates earlier findings in which DAIM was used for teaching other abstract concepts (e.g., Diwu & Ogunniyi, 2012; George, 2014; Ghebru & Ogunniyi, 2017; Hlazo, 2014; Ogunniyi & Hewson, 2008; Philander & February, 2016).

Are grade seven learners' conceptions of conservation of energy related to their age, gender, or language?

The findings show that the learners' from the experimental group's conceptions of conservation of energy were not significantly related to their age, gender, or language. It could be assumed that the learners' comprehension of the concept was relatively based on their everyday encounters with the phenomenon, which all the learners experience in different ways. Since everything that happens in the universe obeys this fundamental law (Woodford, 2017).

5.3. Implications to instructional practice

Findings in this study have shown like others that DAIM has the potential for facilitating learners' understanding of abstract concepts. Therefore, it could be found handy and useful by teachers desiring to adequately involve their learners in a learning process. This is because unlike traditional instruction where teachers tend to dominate classroom discourses, DAIM allows learners to get into dialogic learning. As it is well known, learning scientific concepts and their definitions through memorisation or rote-learning does not impact learners' understanding in any significant way, whereas they should be partakers of the scientific discussions. Klemm (2007) affirmed that "rote memorization is not only inefficient, but it encourages learners not to think – just memorize" (P.62) and this might "block creativity and cut down imagination" (Li, 2004, p. 81). Collaborative learning empowers learners to become good thinkers and it creates room for a better understanding of scientific phenomena (Newell & Beach, 2011).

Opitz et al. (2017) suggested that presenting learners' conceptions concerning four aspects of energy would make findings more meaningful for researchers and educators from different science disciplines and more explicit instruction would be required for learners' intermediate understanding of the concepts. On that note, this study incorporated the four aspects of energy in finding out the learners' conceptions on conservation of energy; the findings revealed the trends in the learners' misconceptions. Furthermore, DAIM improved the learners' scientific understanding through argumentative skills. This instruction helped them to integrate their understanding across the four energy concepts. I also was able to identify a few learners who expressed a scientific understanding of the concept but decided to hold back their alternative conceptions about the concepts after the post-test. The implication is that, to build on and to expand learners' knowledge, it is worthy for the teachers to be equipped with adequate instructional strategies (such as DAIM) that could enable them to examine the learners' conceptions on any scientific topic and some other subjects as opposed to them by being dependent only on the traditional method which limits the learners' understanding. Therefore, learners should be involved in classroom discussions where evidence with facts should be provided in scientific learning, in that way they construct knowledge.

Puzio, Keyes, Cole, & Jimenez (2013) have suggested that in multicultural classrooms, teachers should deploy differentiated teaching and learning approaches. For the same reason, this study adopted DAIM that allowed the learners to discuss, argue, dialogue, and even use their indigenous languages to reach a collaborative consensus on a subject matter.

The quest for a better teaching strategy by West and Meier (2020) suggested that overcrowded classrooms with a population of thirty-three learners to one teacher posed a challenge in South African schools as it contributes to poor learning conditions in schools. The results of this study support the idea and suggest the Dialogical Argumentation Instructional Model (DAIM) be a possible instructional strategy that could help inform teachers' teaching in an overcrowded classroom of about 40 learners on the effectiveness of DAIM. This teaching strategy incorporates a larger number of learners in a classroom and actively involves individual learners in classroom learning that would transform their noise-making into a scientific thoughtful discussion with commitment.

5.4. Implications for teacher education

The evidence from this study gives an insight into how science teachers' knowledge and skills could be greatly enhanced as they look for more effective ways to improve their instructional practices and the skill that are needed to partake in it (Kuhn, 2010). It is therefore, suggested that workshops and seminars should be organised to educate both preservice teachers and in-service teachers on argumentation approach and skills, that would enable them to improve their teaching techniques/methods which would impact learners effectively.

The findings of this study suggest that during argumentative lessons, teachers should not pose themselves as an autocrat due to their virtue of the content knowledge. However, they should have in mind that learners in the classroom also have various forms of knowledge or experiences that they have accumulated over a long time and such experiences could perceive how they receive the new knowledge. Therefore, the teacher should play a role of a facilitator and a mediator of the discussion in such a way that would help the learners understand the content knowledge and help them bridge the gap between their old experience (alternative knowledge) and the new knowledge (scientific knowledge).

Darling-Hammond et al (2020) suggest that teachers should organize teaching materials to be learned in ways that enable learners to fit them into a coherent framework and teach it in ways that allow application and transition to new situations as such teaching methods actively incorporate problem-solving. Therefore, group work is an important part of any activity in the classroom hence, the teachers should serve as a classroom mediator and promote the scaffolding process of learning by helping learners to overcome the cognitive tension that can arise during the learning process through intra-, inter-and trans-dialogue (Ogunniyi, 2005). In as much as that is done, teachers should also be mindful of the socio-economic circumstances of the classroom learners.

The evidence from this study suggests that prospective science teachers should also be motivated to become researchers to prevent misconceptions concerning particular topics in science subjects.

5.5. Recommendations

Ogunniyi, (2016) pointed-out on how the emergence of multicultural learners in our present classrooms in South African schools and beyond posed a great challenge in the educational system to both teachers and second language learners. He further recommended that teachers must of necessity deploy instructional strategies in the languages that would make the topic clear to learners by using the appropriate language(s) of instruction (either bilingual or multilingual instructional approaches) to accomplish the goal of the lesson (Ogunniyi, 2019).

This study recommends that teachers should be trained on how to use the Dialogical argumentation instructional model (DAIM) in science classrooms and other related subjects. This will improve the practices of science teaching and learning at all levels.

Findings in this study have revealed that grade seven learners' age did not have any significant influence on the learners' conceptions of conservation of energy. This was as a result of the collaborative involvement of the experimental group learners' during dialogical argumentation instructional lessons. The learners' involvement and participation enhanced each individual's understanding and performance irrespective of their age. Although, studies such as that conducted by Ünal (2019) affirm that age differences in a classroom affect learners' performance in learning since their performance evaluates their conceptual understanding of any subject content. However, this study seems to have proved otherwise after the involvement of DAIM in this study. Therefore, it is suggested that future research should be conducted similarly by involving more schools at different grades with a focus across the learners' age, as this would contribute to developing the learners' passion and knowledge of science among different ages.

The results of this study have also shown that even after a relatively short time (6 weeks) of exposure to DAIM, most learners have been able to understand the four aspects of energy with a great deal of focus on energy conservation. What one could deduce from this finding is that DAIM has the potential for facilitating learners' understanding of abstract scientific concepts especially because it promotes a learning environment that encourages all learners regardless of their socio-cultural backgrounds to express their views freely, clear their doubts, and even change their views in the face of more convincing arguments by their classmates. In addition, DAIM facilitates learners' reflectivity, critical thinking, and reasoning ability. In light of this, this study recommends the implementation of argumentation instruction, especially DAIM at all levels of the educational system.

A recommendation is made for further research to be carried out among pre-teachers conceptions of conservation of energy, as this will give more insight into teachers' views about the abstract concept.

It is also recommended that new researchers should be mentally, emotionally, physically, and financially prepared before embarking on any research to confidently resolve or prevent certain unpredictable circumstances that might erupt during the research process.

5.6 Limitations of the study

Ross and Bibler-Zaidi (2019) described limitations as "those constrains a researcher could not control that placed certain restrictions on the research process that could influence outcomes of the study. They further contend that all studies have limitations" (p. 261). Following that Ioannidis (2007) indicated that research limitations serve an important part in any scholarly process and it places research findings into context and credibility level. Therefore, the main limitations of this study were found from the sample being drawn from the population as two schools were proposed for this study.

Firstly, access to carry out the research in most primary schools was denied by their principals. Their reasons were that the second term was short, and they had limited time to cover their second term academic syllabus as such, they found it difficult to spare their learners for such research. However, the first public school that accepted my request to carry out the research operates their school session on a half-day basis, and they commence classes in the morning and close at noon. To minimize a biased attitude, I decided to scout for a second school with the same operating system as the former within the same geographical area. Although the second school was found, a lot of considerations were made in terms of the comparability of the two schools.

However, after the pre-test was completed, it was noticed that the learners from both schools were only Xhosa speakers and the English language was only used as their mode of instruction. This restricted the findings to be based only on Xhosa speakers' order than other language speakers for example Afrikaans, Zulu, English, Sepedi, etc. This made the researcher use the cloze text data to analyse their use of scientific words in the understanding of conservation of energy.

During the study I discovered a few learners who had difficulty with the English language and unfortunately I also could not speak peak or understand isiXhosa, the learners' home language. As a result, all our interactions and explanations were communicated in the English language. The use of the English language as a medium of instruction to such learners may have affected their performance. This is because some of them found it difficult to express themselves and thoughts clearly during classroom discussions. They tended to mix their vernacular with the English language. The learners also might have provided the kind of answers that they thought I wanted to hear. However, the use of more than one instrument has helped me to determine the kind of understanding that was developed by the learners.

Another challenge was the disruption of experimental group classes with sports activities after the commencement of the intervention. As earlier stated, the period allocated by the school for this study was in the afternoon from 1H00 – 2H00pm (1hour). During week-two of the intervention, the school administrator allocated the same time of my research for sports activities and rehearsals in preparation for the provincial music competition (extra-curricular activity). Unfortunately, most of the participants (Above average learners) were involved with the Music and cultural dance competitions. Those who were not part of the activities but could not endure staying after school hours seized the opportunity to quit the study. I was left with less than half of the selected learners. Amidst that, those that continued with the study complained of hunger. This ameliorated into providing food for the learners with permission granted by the Head of Department (HOD) of Natural science to avoid losing them. I incurred more cost and unplanned expenses as a result. One of the learners even wrote this in her jotter, “cry we are hungry Miss Malin”. See the learner’s book (Figure 9).

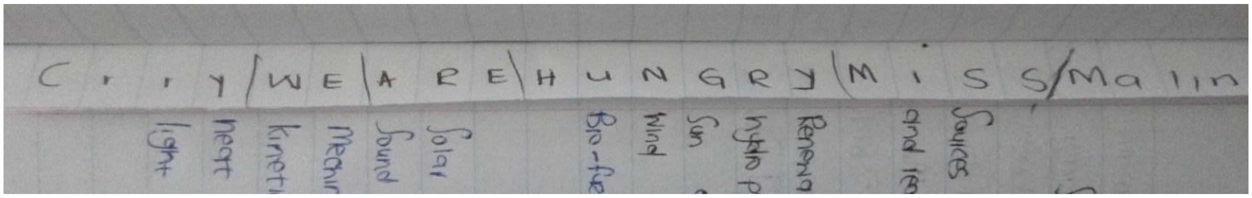


Figure 9: Extract from a learner’s book

According to Winicki and Jemison (2003) learners with signs of hunger learn less during classroom activities. Alternatively, to feed them in class, a learner must not be absent and would increase the probability of learning and be cognitive alert (Ke & Ford-Jones, 2015; Winicki & Jemison, 2003).

5.7 Conclusion

This study has examined the conceptions on conservation of energy among grade seven learners in two Cape Town Schools. It was found that the grade seven learners had several alternative conceptions about the phenomenon. However, after their exposure to DAIM and traditional instruction, they were found to exhibit a better understanding of the concept generally than was the case before the intervention. However, the experimental group exposed to DAIM outperformed their counterparts in the control group. In other words, DAIM appeared to enhance the learners’ understanding of the conservation of energy.

Other encouraging findings were obtained through classroom observation. The findings demonstrate the positive impact both the instructional and social interaction had on the learners’ intellectual reasoning during the process of learning. The learners used different levels of argumentations and on the verge of discussions, CAT’s categories of thoughts tend to manifest congruently within the individuals as they present their written and oral facts. There was a positive trend in such a collaborative process in understanding the conservation of energy. The general results of this study were ensured by providing direct knowledge about what occurred in the classroom.

After the intervention with DAIM, the learners from the experimental group acknowledged the impact of the new teaching method on how it improved their understanding of the concepts of energy and conservation of energy. They shared their opinion on the need for such a teaching approach to be used in teaching them other subjects such as mathematics, they seek to be granted opportunities for the interchange of views on topics of their mutual interest and share their ideas and discuss them with different learners. These learners also assured that DAIM motivated them towards developing more interest to study science.

After the intervention, it was also found that the learners' conceptions were not significantly influenced by their age, gender, or language. This implies that the application of DAIM bridged the gap of any existence relative to age or gender effects in the classroom.

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APPENDICES

APPENDIX A: Letters of permission and approval letter

Directorate: Research
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Fax: 0865902282
Private Bag x9114, Cape Town, 8000
wced.wcape.gov.za

Western Cape Government
Education

REFERENCE:20190328-3167
ENQUIRIES: Dr A T Wyngaard

Ms Malin Okoroh
45 Old Paarl Road
Bellville
7535

Dear Ms Malin Okoroh

RESEARCH PROPOSAL: CONCEPTIONS OF CONSERVATION OF ENERGY AMONG GRADE 7 LEARNERS IN CAPE TOWN SCHOOLS

Your application to conduct the above-mentioned research in schools in the Western Cape has been approved subject to the following conditions:

1. Principals, educators and learners are under no obligation to assist you in your investigation.
2. Principals, educators, learners and schools should not be identifiable in any way from the results of the investigation.
3. You make all the arrangements concerning your investigation.
4. Educators' programmes are not to be interrupted.
5. The Study is to be conducted from **02 April 2019 till 31 May 2020.**
6. No research can be conducted during the fourth term as schools are preparing and finalizing syllabi for examinations (October to December).
7. Should you wish to extend the period of your survey, please contact Dr A.T Wyngaard at the contact numbers above quoting the reference number?
8. A photocopy of this letter is submitted to the principal where the intended research is to be conducted.
9. Your research will be limited to the list of schools as forwarded to the Western Cape Education Department.
10. A brief summary of the content, findings and recommendations is provided to the Director: Research Services.
11. The Department receives a copy of the completed report/dissertation/thesis addressed to:
    The Director: Research Services

Western Cape Education Department
Private Bag X9114
CAPE TOWN
8000

We wish you success in your research.

Kind regards.
Signed: Dr Audrey T Wyngaard
Directorate: Research
DATE: 29 March 2019

Lower Parliament Street, Cape Town, 8001
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Safe Schools: 0800 45 46 47

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Employment and salary enquiries: 0861 92 33 22
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6 November 2018

Ms NEM Okoroh
Faculty of Education

Ethics Reference Number: HS18/5/38

Project Title: Conceptions of conservation of energy among grade seven learners in Cape Town Schools.

Approval Period: 05 November 2018 – 05 November 2019

I hereby certify that the Humanities and Social Science Research Ethics Committee of the University of the Western Cape approved the methodology and ethics of the above mentioned research project.

Any amendments, extension or other modifications to the protocol must be submitted to the Ethics Committee for approval.

Please remember to submit a progress report in good time for annual renewal.

The Committee must be informed of any serious adverse event and/or termination of the study.

Ms Patricia Josias
Research Ethics Committee Officer
University of the Western Cape

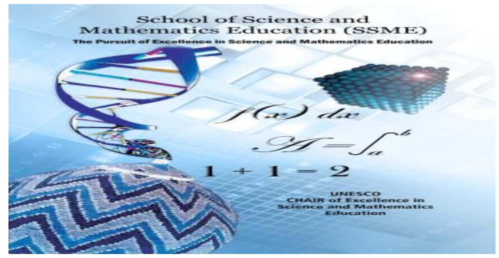
PROVISIONAL REC NUMBER - 130416-049

A HOPE TO ACTION THROUGH KNOWLEDGE

SCHOOL OF SCIENCE AND MATHEMATICS EDUCATION

(SSME)

UNIVERSITY *of the* WESTERN CAPE



School of Science and Mathematics Education
Faculty of Education
University of the Western Cape
Robert Sobukwe Road
Private Bag X17, Bellville, Western Cape

Tuesday, 2nd April, 2019
The Principal,
North Primary School,
Mfuleni, Cape Town.
Dear Sir/Ma'am,

RE: REQUEST FOR PERMISSION TO CONDUCT A RESEARCH IN YOUR SCHOOL

I, Ms. Malin Okoroh, a Masters student in the School of Science and Mathematics Education (SSME) at the University of the Western Cape (UWC) seek for your permission to carry out a research study in your school for a period of six weeks. The title of the study is: "Conceptions of Conservation of Energy among Grade Seven Learners in Cape Town Schools". The research study will include data collection among grade 7 learners (Intermediate phase). This entails the administration of a questionnaire in form of a Science Achievement Test (SAT) and a focus group interview with some of the learners.

The motivation to undertake the study emanated from my previous experiences in teaching grades 7 – 10 learners as well as inadequacies identified by national and international assessments e.g. TIMMS. The study tends to use Dialogical Argumentation Instructional Model (DAIM) as an instructional approach to help learners learn previously mentioned concept meaningfully. DAIM is an innovative teaching method that has been approved internationally. DAIM has been found in many parts of the world to be effective for teaching difficult concepts such as conservation of energy. The method has been used among learners even the lower grades such as grades 3-6 in several countries including South Africa which is mutually beneficial to learners.

Importantly, my research proposal has been approved by the Deputy Dean of Research in the Faculty of Education. I plan to use your school in the remaining weeks of Term 2, from month of April-May 2019.

I have already received an approval letter from Research Director, Western Cape Department of Education and Research Ethics Committee of the University of the Western Cape. I promise to work strictly within ethical rules stipulated by the Ethical Committees.

All the information gathered shall only be used for the research purposes and the name of your school and the learners involved shall not be disclosed to the public or individuals.

At the end of my study your school will be provided a summary of the findings of the study as a way to add to their knowledge based on learners' learning of conservation of energy using DAIM. I shall be grateful to receive your approval to conduct this study.

Please, attached are the copies of the approved letter from WCED and UWC ethical committee for your perusal.

For further information, kindly contact my supervisor Prof. Meshach Ogunniyi- mogunniyi@uwc.ac.za 021-9592040 or 0738605130.

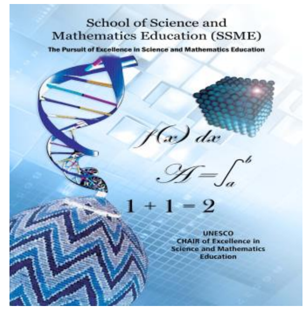
Thanks.

Best Regards,
Malin Okoroh
E-mail: 3877576@myuwc.ac.za; Cell: +27847189146)

SCHOOL OF SCIENCE AND MATHEMATICS EDUCATION

(SSME)

UNIVERSITY *of the*
WESTERN CAPE



April 21st, 2019.

PROJECT TITLE: CONCEPTIONS ON CONSERVATION OF ENERGY AMONG GRADE SEVEN LEARNERS IN TWO CAPETOWN SCHOOLS

ASSENT FORM

Dear Participant,

I_________________________________ give my assent to participate in the research on "*conceptions of conservation of energy among grade seven learners*". Please **tick** the appropriate boxes.

I understand that:

- The research will be beneficial to me and I'm willing to withdraw if not comfortable with the activities involved. ☐
- The audio recordings and the transcripts will not be seen or disclosed to anyone else other than the researcher and her supervisor. ☐
- The audio recordings and the transcripts will be kept in a password protected computer ☐
- Although the responses from questionnaires, science achievement tests and interview will be used in the research report, but it will be referred to by a pseudonym. ☐

Thank you.

Participant's signature………………….

Date………………………………….

APPENDIX B: Lesson Plan

Lesson Plan: Instructional Component and Context

Lesson Orientation: ***Teacher (as a mediator) will provide the following useful information to the learners.***

Mediator: Explains the following terms to the learners:

- **Claim -a statement that has not be tested or agreed to by others.**
- **Grounds - (data, warrant, reason, evidence or fact that you can see) That support your claim**
- **Rebuttals - the opposite of your claim**

Mediator: Draws learners' attention on the following: importance of listening to others when they are talking, respect for one another, when and how to give their opinions on different sides to an issue. It may be to agree or disagree, with others.

Mediator: Explains how the individual, small-group and whole-class tasks are to be completed. In this sense, my task is to mediate the processes of argumentation.

Mediator: Makes provision of learning materials (e.g. prepare posters, marker pen, show how learners on how to construct journals, etc.). Divides learners into groups and allocation of roles.

TOPIC	LEARNING OUTCOMES	STRATEGIES	Learning Aids
WEEK 1: 24/04 – 16/05/2019	**L.O 1 - 3**	**Argumentative & Discursive Approach**	
<u>LESSONS 1 &2 </u>: (2 x 45 mins) Observation & discussing "energy" and its sources. **<u>Activity Tasks</u>** ***Learner complete Argumentation framework worksheets using observation, Testing & practical reasoning skills** or **background to evaluate conservation of energy***	**<u>Learners should be able:</u>** ✓ Recognizing instances where different forms of energy are used and their basic features like sources and changes. ✓ Predict sources of energy and give basic features. ✓ Make comparative judgement about energy types – **<u>Additionally learners will:</u>** Develop an appreciation of discursive and argumentative activities, hence stimulating their reasoning process skills leading to broad mindedness.	**<u>Lesson Introduction & displays: </u>(5 mins)** **<u>Activity 1: Individual Task </u>(15 mins)** ✓ Each learner completes an individual task. **(No discussion)** **<u>Activity 2: Group discussions </u>(15 mins)** • **Learners** discuss each other's claim and grounds and come to a group conclusion about claim &grounds. (10 mins) • **Group leader** to scribe group's claim and grounds. (5mins) **<u>Lesson recalling</u>** **<u>Activity 3: whole class</u> (10mins)** ➢ **Teacher &Learners** compares Group claims &grounds **<u>Summary notes</u>** Learner individually writes down notes summarizing the lesson.	**<u>LA:</u>** • Learner worksheets and pens, posters, audio tapes, materials, pictures, charts, etc.

APPENDIX C: Exemplar lesson worksheets for the E-group with DAIM

LESSON 1Activity 1 (Individual task) Name:____________________

Energy is a very important part of all our lives. ENERGY is the POWER that makes things WORK. The story of Sipho tells us more about this.

In each of the following questions, write your **view** as your **CLAIM** and state your **reason(s).**

1. It's eight o'clock in the morning and Sipho is still asleep. Is he using **ENERGY**?

My answer/claim is: ____

My reason/evidence: ____

2. The alarm clock goes off. Sipho wakes up and gets ready for school. Is he using **ENERGY**?

My answer/claim is: ____

My reason/evidence: ____

3. Time for some breakfast. Is he using **ENERGY**?

My answer/claim is: ____

My reason/evidence: ____

4. Sipho is travelling to school by bus. Is he using **ENERGY**?

My answer/claim is: ____

My reason/evidence: ____

5. Sipho working hard in school. Is he using **ENERGY**?

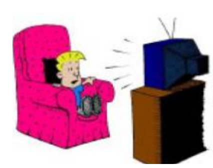
My answer/claim is: ____

My reason/evidence: ____

6. Sipho is home again, finished his homework and settled down to watch some television. Is he using **ENERGY**?

My answer/claim is: ____

My reason/evidence: ____



<u>Lesson 1. Activity 2</u>(Group task) Group no.______________

By now you must have completed activity 1, **the individual task** (questions 1-6). Now follow these easy steps with your group members.

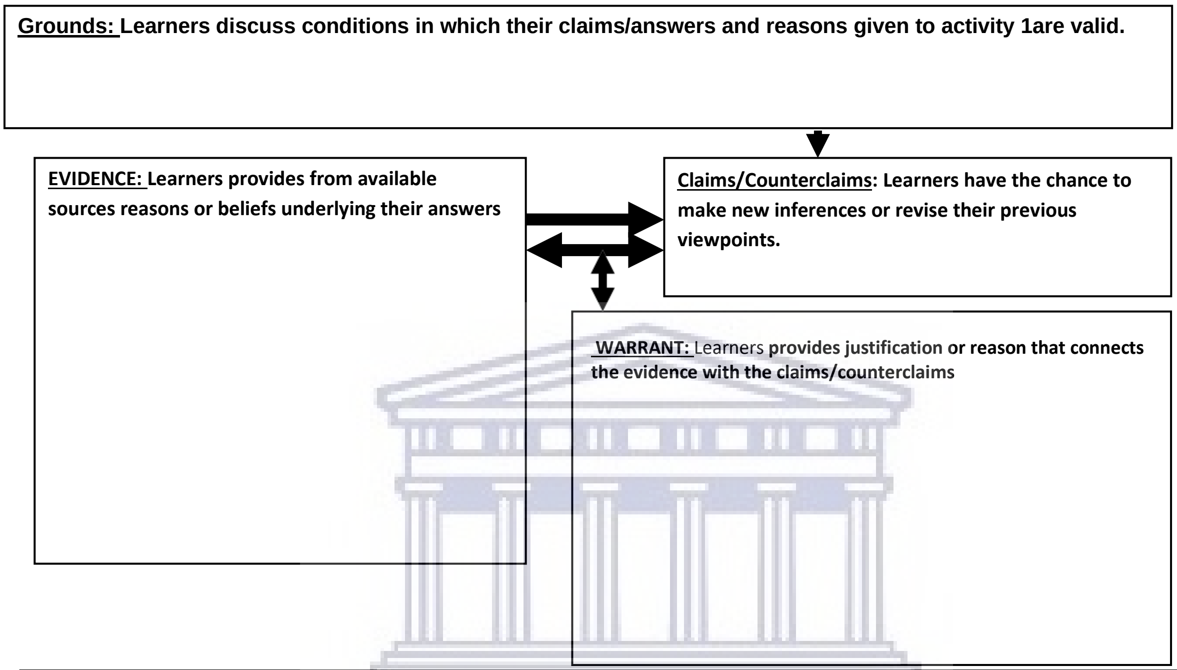
1. For each of the question, every member of your group must tell the group what his/her answer/claim and reason are.
2. Discuss each other's answer/claim and reason to decide which answer and reason are correct.
3. Write down the **<u>reasons of your disagreement for each question</u>**.
4. Make a decision. Remember you are like a soccer team; you must work together to score a goal. So, it doesn't matter who scores the goal (that is, it doesn't matter whose answer/claim and reason the group is choosing), what matters is that when the team scores a goal, everybody is a winner.
5. After you have decided which answer/claim and reason that you are going to take for each question, write it in the table below.

Q #:	Claim	Evidence/Reason or Ground	Reasons of your disagreement

6. **Group presentation.** Your group leader or any member you have chosen must present your work to the class. During the presentation, members of other groups may agree or disagree with your answers/claims and reasons. Be prepared to defend your answers and reasons. This must be done with respect for one another even when others do not agree with you or you agree with them. Keep good manners. Think to use the reasons of your disagreements to each of the question you wrote in

the table to support your views.

Lesson 1 Activity 3 Whole group discussion: Teacher mediates discussion, help learners reach consensus.



Teacher Activity (as mediator) discusses what learners seem to agree upon.

Teacher's final thoughts/Reflection:

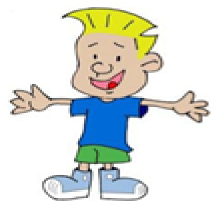
LESSON 2, Activity 1(Individual task) Name:_____

In lesson 1, we learnt from the daily activities of Sipho what we need energy for.

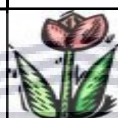
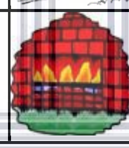
By now you can think of loads of things that need energy to make them work! For example:

A tree needs energy to grow... Our bodies need energy to move... A car needs energy to go...

Today Sipho wants to know, where does all this energy come from? We are going to help him to find out!



1. See if you can fill in the energy resources in the table below.

Energy source	Energy source
	
	
	

2. What happens when a car or bus is started? What do you hear, see, smell and feel?
My answer/claim is: ______________________________ M
reason/evidence: ______________________________

3. When the engine starts, we switch on the radio or beep the horn, we ca
is sound energy. Where does it come from?
My answer/claim is: ______________________________
My reason/evidence: ______________________________

4. Can energy change?
My answer/claim is: ______________________________
My reason/evidence: ______________________________

5. Look at each one and try to work out what the two main kinds of energy are.

a. A drum changes **mechanical** energy into __________energy.
b. An electric heater changes ________energy into________ energy.
c. A light bulb changes ____________energy into_________ energy.
d. Our bodies change __________energy into ____________energy.
e. A kettle changes __________energy into _____________energy

<u>Lesson 2. Activity 2</u>(Group task) Group no.______________

By now you must have completed activity 1, **the individual task** (questions 1-5). Now follow these easy steps with your group members.

1. For each of the question, every member of your group must tell the group what his/her answer/claim **is** and reasons are.
2. Discuss each other's answer/claim and reason to decide which answer and reason are correct.
3. Write down the **<u>reasons of your disagreement for each question</u>**.
4. Make a decision. Remember you are like a soccer team; you must work together to score a goal. So, it doesn't matter who scores the goal (that is, it doesn't matter whose answer/claim and reason the group is **chosen**), what matters is that when the team scores a goal, everybody is a winner.
5. After you have decided which answer/claim and reason that you are going to take for each question, write it in the table below.

Q #:	Claim	Evidence/Reason	Reasons of your disagreement

6. **Group presentation.** Your group leader or any member you have chosen must present your work to the class. During the presentation, members of other groups may agree or disagree with your answers/claims and reasons. Be prepared to defend your answers and reasons. This must be done with respect for one another even when others do not agree with you or you agree with them. Keep good manners. **Think of using** the reasons of your disagreements to each of the question you wrote in the table to support your views.

Lesson 2 Activity 3 Whole group discussion: Teacher mediate discussion, help learners reach consensus

Grounds: Learners discuss conditions in which their claims/answers and reasons given to activity 1are valid.

EVIDENCE: Learners provide from available sources reasons or beliefs underlying their answers

Claims/Counterclaims: Learners have the chance to make new inferences or regulate their previous viewpoints

WARRANT or JUSTIFICATION: Learners provide **justification that connects the evidence with the claims/counterclaims**

Teacher Activity (as mediator) discusses what learners seem to agree upon.

Teacher's final thoughts/Reflection:

LESSON 3, Activity 1(Individual task) Name:______________________

In our previous lessons, we learnt from the daily activities of Sipho what we need energy for and where this energy comes from. Today, Sipho also wants to know where this energy goes to after it has been used. Let's help him and find out…

6. Light a candle and watch carefully how the flame burns. Take a piece of metal. Place one end of the metal in the flame and hold it for few seconds. Explain what you observed?

My answer/claim: ____

My reason/evidence: ____

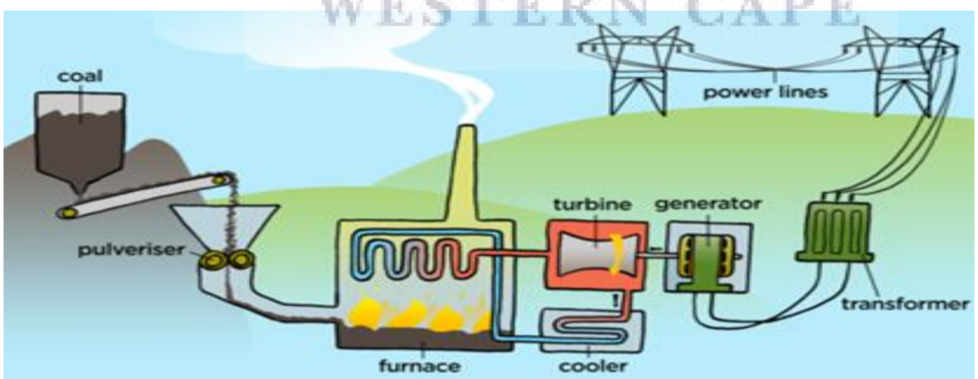
7. What happens to the energy the wood generates when it burns?
My answer/claim: ____

My reason/evidence: ____

8. Do you think the energy generated in the wood still have the same energyafter it had burnt? Where did the energy go to?
My answer/claim is ____

My reason/evidence ____

9. For the fact that human beings process coal to generate electricity and also manufacture other electrical gadgets that supplies us with different forms of energy. Does that mean energy is being created?



My answer/claim is ____

My reason/evidence ____

____

Lesson 4. Activity 1(Individual task) Name:_____

TASK ON CONSERVATION OF ENERGY

Important Notes for You

Argumentation** is the process of making a **claim** and providing **proof** as **justification** (*something to be right) ***to support the claim.

Important elements of Argumentation:

- **Claim -** *A claim is when you make a statement about what you believe in and wants another person to accept it. Or* a statement that has not been tested or agreed to by others.
- **Grounds -** (data, warrant, reason, evidence or fact that you can see) that support your statement or claim
- **Rebuttals -** the opposite of your claim or to make a comment that is against your claim.

Scenario 1

Asanda's mom bought a brand new cell phone, after reading the instruction she decided to plug the phone for it to be fully charged before she can turn it ON. Out of excitement Asanda suggested to her mom, why can't you turn ON the phone to see if it will go ON or not? Her mom said no, it is a new phone so where will it get the energy to start with, I must create energy first.
Asanda: Mom, can you really create energy?
Asanda's mom: Yes, why not? My child, you see, in life it is either we are creating things or we are destroying things.
Asanda: Does that apply to energy as well?
Asanda's mom: Of course, it applies to anything.
Asanda: Mom, but our class teacher told us that energy cannot be created or destroy, but can only be transformed…
Asanda's mom: If you say so, are you saying if I switch ON the phone it will start?
Asanda: Yes mom, I think so. Usually new phones come with charged batteries.
Asanda's mom: Wow! It's ON…I didn't know that. You are so clever my daughter, high five!

1.1 What do you think Asanda and her mom were doing?
We think they were……____

1.2 One of your classmates thinks that Asanda's mom was right to say she can create or destroy energy?

1.2.1 Do you agree? (Yes) (No)

1.2.2 My reason(s)…… ____
____

1.3 Copy the *sentence* in the scenario that shows the first **claim** made by Asanda's mom.
Asanda's mom made a **claim** when she says……____

1.4 Where does the energy in a fully charged battery goes to after being used and the battery is left empty?

1.4.1. My claim is …____

1.4.2. My reason/ evidence is that…. ____________________________________

Lesson 3. Activity 1(Individual task)   Name:_____

Scenario 2

Sipho's Father drives a delivery truck every day to deliver food parcels to small grocery shops. Sipho has always wanted to help his father to do delivery work. But his father would not allow him to do so because he feels that it would affect his schooling. So one day during the school holiday his father decided to let Sipho go with him. As they were driving on a busy N2 road their delivery truck suddenly stopped. Sipho's father got out of the truck to have a look at the engine. He found out that everything seems okay except that the truck can't just start.

Sipho: Dad, is everything okay?
Sipho's father: No son, we just ran out of energy…no more energy left in the truck so the engine won't start.
Sipho: Uhm…sigh…so where has the energy gone to, dad?
Sipho's father: Certainly, the energy must have been destroyed.
Sipho: Destroyed? ....dad, can energy be destroyed?
Sipho's father: Oh yes, my boy…if we can create energy, we can also destroy it…things work like that.
Sipho: Dad…but energy cannot be created or destroyed but only transform from one form to another…
Sipho's father: So what do you think has happened to the energy of the truck?
Sipho: Dad…I think the energy of the truck has been transformed into heat, sound…
Sipho's father: Clever boy, so how did you know all of this when you are not a mechanic?
Sipho: Our teacher taught us…so, Dad do you agree with me?
Sipho's father: Uhm…yes for now…

2.1. Copy the *sentence* in the scenario that shows the first **claim** made by Sipho's father. Sipho's father made a **claim** when he says………..______________________________

2.2. What source of energy does Sipho and his father referring to?
  2.1 My claim ____
  2.2 My-reason/evidence
  ____

2.3. One of your classmates thinks that Sipho's father was right to say,' if we can create energy, we can also destroy energy.
  2.4.1 Do you agree? (Yes).   (No)
  2.4.2 My reason/ evidence,.______________________________________
  ____

2.4. Do you think the energy in the truck transformed into other forms of energy which caused the truck to stop or it simply got destroyed?
  2.4.1. My claim is that______________________________________
  2.4.2 My reason/evidence is that ________________________________

APPENDIX D: Observation check list

ARGUMENTATION AMONG GRADE 7 LEARNERS (Small Group discussion)	GROUP CONSTRUCTION AND EVALUATION OF ARGUMENT																											
	1				2				3				4				5				6				7			
RATING SCALE	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3
Talking and listening to other groups																												
Use elements of argument in conservation of energy discussion																												
Constructing ideas using well-articulated and structured view points																												
Frequent counter-arguing to strengthen either own group's views or other groups																												
Reflecting on argumentation process, group/individual resolving anomalies embracing conceptual change																												
Pre-Test																												
Post-Test																												

The Rating Scales [Observation checklist E-Group]

The rating scale shows the frequency of actions taking place during classroom teaching with DIAM. The numbering scale does not conform to a negative judgment of the quality of actions display by the learners. Neither does it target who wins or who loses. Rather it represents the frequency of the learners in the argumentative discourse of small groups. It also organize the manner of their adaptability to the elements of arguments as well as the level of each group's involvement. The meanings of the numbers are:

Number 1- 7: Different Groups.

1 -Silence
1- Not at all
2- Some of the time
3- Frequently

APPENDIX E: Research Instruments

SCIENCE ACHIEVEMENT TEST

The purpose of this test is to determine your understanding of what is meant by conservation of energy. Please fill each section below carefully. The information you provide will be used only for research purposes and will not be used against you. Your answers will be kept confidential.

Section A

Please mark X in the box where applicable to you.

AGE: 11years ( ) 12years( ) 13years ( ) 14years( )15Years or more ( )

GENDER: Male ( ) Female ( )

HOME LANGUAGE: IsiXhosa ( ) IsiZulu ( ) Sotho ( ) Afrikaans ( )

Others (Please specify ……………………….)

PLACE OF BIRTH: …………………….………….

PRESENT PROVINCE: ……………………………………………………….

RACE: Black ( ) Coloured ( ) White ( ) Indian ( )

Which of the following items do you have in your house?
Car ( )Electric kettle ( ) Radio () Television () Torchlight () Books ( ) Electricity ( ) Study table (

EDUCATION OF PARENTS: Primary school ( ) Secondary ( ) Tertiary/higher institution ( ) vocational education training (VET) () College ( ) University ( )

Big Ideas: For your attention

• Energy (Amandla) is needed to make everything work, move or live
So what do we mean when we say 'source of energy'?
• A source of energy has energy stored waiting to be used, or energy that is needed to make something happen.
We have two types of *sources of energy*

1. Non-renewable sources of energy cannot be replaced once it is used, e.g. fossil fuels (coal, oil, natural gas).
2. Renewable sources of energy are continually refilled e.g. hydro power, wind, sunlight, biofuel (wood).

Note: The law of Conservation of Energy tells us that energy cannot be created or destroyed (ukutshabalalisa), but can only be transformed from one type of energy to another.

Section B

Individual Task: You are expected to complete this section of task on your own.

Question 1

1.1 What is energy (Amandla)?
……………………………………………………………………………………………..

1.2Where do we get energy (Amandla)? ……………………………………………….

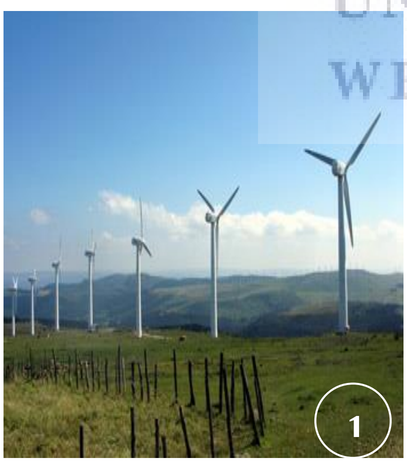
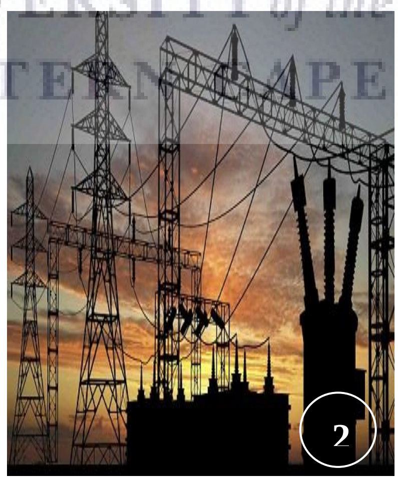
1.3 How do we use energy in our everyday lives? ……………………………………………

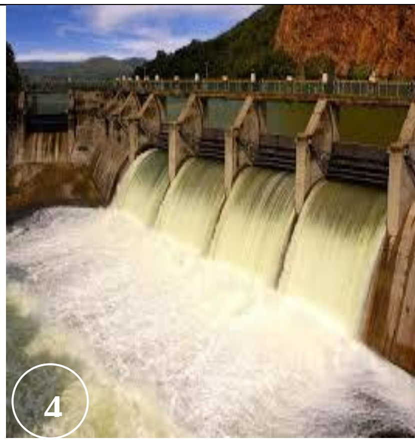
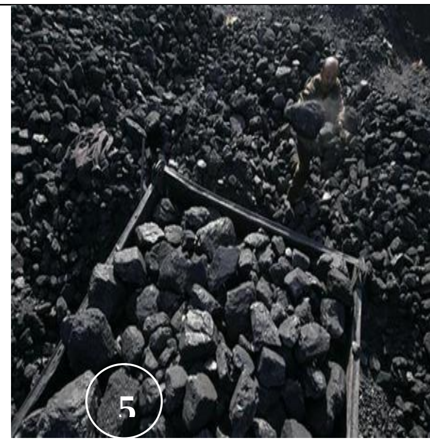
1.4 Name three different forms of energy. ………………………….. , …………………… ,

1.5 Do you agree that energy cannot be created or destroyed (ukutshabalalisa)? Yes ( ) or No ( )

My reason is…………………………………………………………………………………..

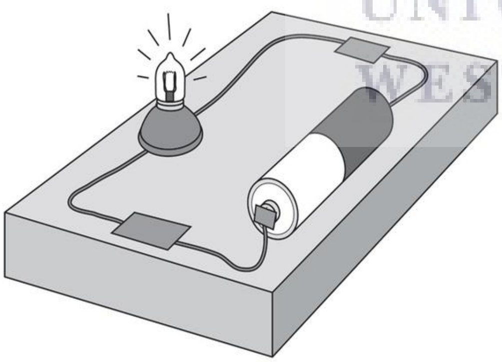
Question 2
The six pictures below show different sources of energy. Name the type of energy source in each of the pictures.

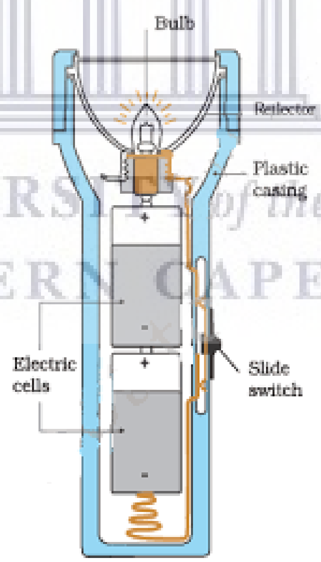
			
Identify energy source			

	4	5	6
			
Identify energy source			

Question 3

Use the illustration in the diagram below toanswer the questions that follow.





3.1 A battery-operated torchlight uses chemical energy, which enables the bulb to glow.

3.1.1 What is the source of energy in both diagrams? ....

3.2 What happens to the energy source as the light bulb glows for a long time?

…………………………………………………………………………………………………

3.3 Name three forms of energy into which the chemical energy of the cells was transformed

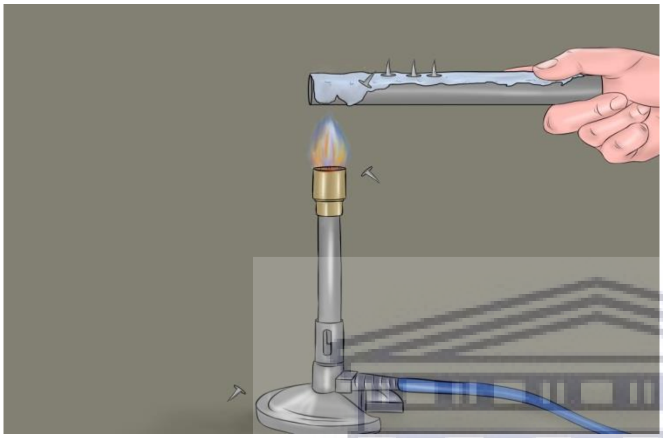
Question 4.

Observe the experiment in the diagram below to answer the questions.

Method:

4.1 Take an iron nail, gum the nails along a piece of metal.

4.2 Hold one end in a fire or flame. As shown in the diagram.



a.) What do you think will happen to the end you were holding after a short while? ……………………………………………………………………………………………………

b.) Can you explain what happened in the diagram?…………………………………………………….

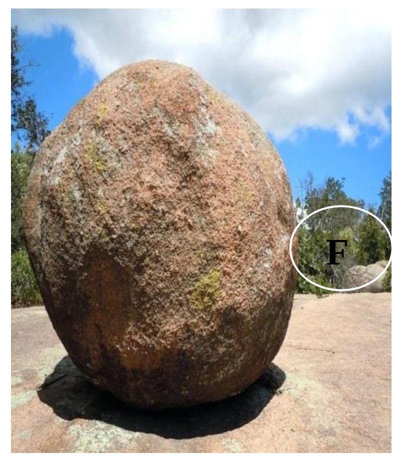
Question 5

5.1The books on the shelf below had a stored energy called potential energy. When the books **fall** as shown in the diagram, this potential energy will be changed into ……………….energy?

5.2 What type of energy keeps the book shelf from falling off the wall?…………………………………………………

Question 6.

The pictures below describe various forms of energy. Carefully observe them and answer the questions that follow.



6.1 (a) List the picture(s) that you feel adequately describes the law of conservation of energy.

……………………………………………………………………………………………

Explain your reason? ………………………………………………

(b) List the type of energy shown by: A……………………B…………………………

C……………………D…………………………E……………………………

6.2 Which of the pictures has nothing to do with the law of conservation of energy?

…………………………………………………………………………………

6.3Which of the diagrams describe an example of mechanical energy?

…………………………...............

6.4 In picture D, if the boy stops the ball from rolling on the floor, will there be a conversion of energy from one form to another? Yes ( ) No ( )

Explain your reason?

…………………………………………………………………………………………

Question 7

Asanda plugged a small quantity of water in an electric kettle. Note that electrical energy which passes current into the kettle makes the water to boil quickly. Asanda noticed 30 minutes later that the water left in the kettle had become so small and that the kettle was very hot. If she had left the kettle **a** little bit longer, the water might be dry completely.

7.1 What do you think had happened to the water in the kettle?

I think ....

7.2 Do you think the water in the kettle reduced because the heat energy in the water had been lost or destroyed?

YES ( ) NO ( )

7.3 The heat energy has been converted into another form as the law of conservation of energy suggests?

YES ( ) or NO ( )

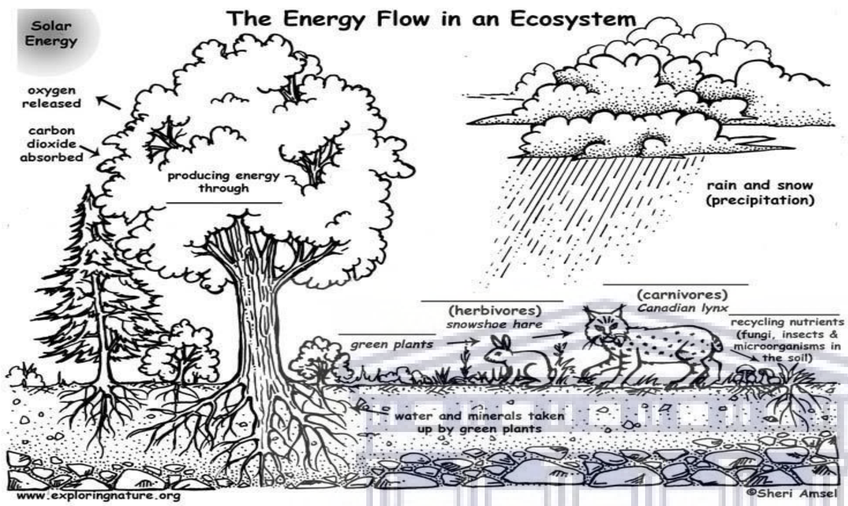
My reason is that …….

……

……

Question 8.

Have you ever thought of what may happen if all the plants on earth die? Well, our beautiful planet will become like a desert. There will be no oxygen for us and the animals to breathe and we will all die. If all plants die, the flow of energy will also stop and all organisms will have no food eat. Study the diagram below carefully and answer the questions that follow.



8.1 Explain how energy flows among the living things in the diagram above?
…………………………………………………………………………………………………
…………………………………………………………………………………………………

8.2 Where does the rabbit get its energy from?
…………………………………………………….
…………………………………………………………………………………………………
….

8.3 Which form of energy in the system is produced by the sun?
……………………………………

8.4 In case the cat dies, what do you think will happen to the energy in its body?
……………………………………………………………………………

Question 9.

Name the different kinds of energy which a rotating fan is transformed into.

Question 10. Draw a diagram to show how energy is transformed from one form to another.

Appendix F: Cloze Test

Fill in blanks in the sentences with the correct words from the box below.

energy, sound energy, electrical energy, potential energy, slope, created, kinetic energy, sound, transferred, form, press, bell, cannot, light energy, converted, dark energy, can, mechanical energy

The Law of conservation of _________ states that energy___________ be created or destroyed, but can be __________________ from one system to another or converted from one __________, to another. For example, consider an electric doorbell: when you _________ the button, _________________ is transferred to the ______________ and the bell makes a ______________. In other words, _____________________ in this system is converted to_________________. The electric windows of a car also illustrate the transfer of ___________in a system. When you push the button to close or open the windows, electrical energy is ________________________to kinetic energy. Stored energy is also called ______________________. If you hold a toy car moving down a ___________ it has kinetic energy. The energy that makes water to boil in the kettle is known as _________________When you ring a bell ____________________is converted to __________________

Sunlight is an example of ________________________

APPENDIX G: Idea about Conservation of Energy Questionnaire (ICEQ)

This questionnaire wants to find out about your idea of conservation of energy. There is no right, or wrong answers so feel free to express your view. The information you provided will be used only for research purposes and will be kept confidential.

Section A.

Please mark (X) in either Agree, Disagree, or Don't know, were applicable to you.

	STATEMENTS	AGREE	DISAGREE	DON'T KNOW
1.	We get all our energy from renewable and non-renewable sources.			
2.	Energy from the sun causes water to be converted (jika/guqulela) into rain through vapour.			
3.	Do you agree with the statement that "when you switch on the fan in your bedroom, the electrical energy gets converted (jika/guqulela) into mechanical energy which causes it to move?			
4.	Energy is converted (jika/guqulela)from the food we eat to enable us do various activities e.g. run, jump and so on.			
5.	Do you think things would be different or remain the same if energy is not conserved?			
6.	Energy is converted(jika/guqulela)from one form to another therefore it cannot be created or destroyed (ukutshabalalisa)			
7.	The Law of conservation of energy can be confirmed by experiment.			
8.	The radio transmits electrical energy into sound energy			
9.	Heat is one of the most important forms of energy we come in contact every day.			
10.	Energy is stored in many stationary objects.			

11.	The energy in motion is called kinetic motion.			
12	Wind is one of the sources of energy.			
13.	Energy cannot be destroyed (ukutshabalalisa) but it can be wasted.			
14.	From all you know, do you think that the conservation of energy is an absolutely true (awukulungelanga), and unbreakable (ayophuleki) law of nature?			

Section B.

***Kindly tick "X" in the boxes below for your answer*.**

1. Have you heard about the law of conservation of energy? Yes ( ) No ( )
2. How well do you understand this law? Very Well ( )Not too Well ( ) I don't understand it ( )
3. Have you ever had doubt about this law being generally acceptable? Yes ( ) No ( )
4. If Yes, which aspect of the law is acceptable? ……………………………………………..
5. Can you share your own experience when you felt the law of conservation of energy was well expressed…………………………………………………
………………………………………………………………………………………..
6. Do you feel this law is important to you in your everyday life? Very Important ( ) Not really Important ( )Not Important ( ). Explain your answer……………………………………………………………………………………
7. Have you ever thought (Icinga) that in some cases the law of conservation of energy does not hold? Yes ( ) No ( )

   a. What were your thoughts (Icinga)? ………………………………………
   ……………………………………………………………………………………
8. Do you think death fulfils the law of conservation of energy? Yes ( ) No ( )
   a. Please explain in your own words………………………………………

APPENDIX H: Attitude towards Science Questionnaire

This questionnaire wants to find out how you feel about science. There is no right, or wrong answers so feel free to express your view. The information you provided will be used only for research purposes and will be kept confidential.

No.	STATEMENTS	AGREE	DISAGREE	DON'T KNOW
1.	I have interest to know new inventions in science			
2.	Science is a difficult subject; no matter the effort I put in it I don't feel hopeful to understand science.			
3.	I don't give up easily, no matter how difficult a scientific idea is.			
4.	When I don't understand a scientific idea, I quickly ask my teacher, parents or friends to help me.			
5.	I find science to be an enjoyable and easy subject.			
6.	During the learning process I find it easy to connect what I learn in science with what I do at home.			
7.	I feel so happy when the teacher accepts my contribution in the science class			
8.	I like to study science because we are allowed to perform experiments and discuss interesting subjects.			
9.	I want to become a scientist in the future			
10.	Although I do not really like science, my parents and teacher force me to learn it			
11.	I do not like science because of the way it is taught in class			
12.	I enjoy science when the content are explained in my home language			
13.	My science teacher encourages me to learn more science			
14.	I like to repair things when they stop working.			
15.	I don't think I have the ability to do science.			
16	I like science because it is a practical subject			
17	I like to watch science movies			
18	I like to study science because it explains how things work			

APPENDIX I: Learner Interview Schedule

Name: ______________________________________ Group: _______________________________

Lessons completed: ____________________________Date: ________________________________

1. What did you like about the argumentation Lesson? __________________________________

2. How is the argumentation lesson similar or different from the way you have been taught in the other lessons? ____

____

3. Does your scientific knowledge change from time to time?

____

4. Did you know that scientists argue before participating in the lessons on Conservation of Energy?

____
____

5. What was most interesting to you about the argumentation lessons? ____________________________

____

6. Do you now argue with your friends, brothers or sisters outside class when you don't agree with their views? ____

____

7. Does brain-storming (self-argumentation) help you to think better now than before?

____

8. What will you like to be changed in the way you are taught in science and other school subjects?

____
____

9. Has your experience in the argumentation lessons helped you to participate more actively in the science classroom or any other classroom than before?

____
____

10. Is there anything else you will like to share?

____
____