THE EFFECT OF VEE DIAGRAMMING ON GRADE SEVEN LEARNERS' UNDERSTANDING OF FORCE

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A mini-thesis submitted in partial fulfillment of the requirement for the degree of M.Phil in the Faculty of Education, University of the Western Cape, South Africa.

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DEDICATION

I dedicate this mini-thesis to my late father, Andreas William Koopman.

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ACKNOWLEDGEMENT

I thank the living God for granting me strength and wisdom throughout this research. According to the Bible:

> Perseverance must finish its work so that you may be mature and complete, not lacking anything. If any of you lacks wisdom he should ask God, who gives generously to all without finding fault, and it will be given to him (James 1:4-6).

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DECLARATION

I declare that **The Effect of Vee Diagramming on Grade Seven Learners' Understanding of Force** is my own work, that it has not been submitted for any degree or examination in any other University and that all the sources I have used or quoted have been indicated and acknowledged by complete references.

OSCAR KOOPMAN

Signature: ....

Date: 11. 11. 04 ....

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ABSTRACT

This study sought to determine grade seven science learners' conceptual understanding of force. A related aim was to determine the effectiveness of Vee diagramming in ameliorating the incorrect conceptions about force held by the learners. The study was conducted in a working class area dominated by high drop-out rate, high illiteracy rate, poorly trained teachers and under-resourced schools.

Three comparable groups of grade seven learners from two primary schools were selected for the research. Both quantitative and qualitative data were gathered. The instruments used for gathering the data included a General Ability Test on force, a Concept of Force Test (COFT), interviews and a student questionnaire. However, before the instruments were administered to the learners eight experts evaluated them by ranking the questions from 1 to 5. A ranking of 1 stood for a poor item while 5 stood for an item of high quality. The correlation of their ratings was determined using the Spearman's Rank Difference formula.

The study adopted a quasi-experimental design modified after Solomon-3 Control Group Design. The experimental group (E, n = 25)) and the second control group (C_2, n = 25)) were exposed to Vee diagramming while the true control group (C_1, n = 25)) was taught through an expository lecture approach. Further, six learners were interviewed from both the experimental and C_2-group to gain a deeper insight into whether or not Vee diagramming enhanced their understanding of the concept of force.

The data were analyzed and discussed against five different levels of understanding ranging from "no response", "no understanding", "misconceptions", "partial understanding" to "sound understanding". The null hypothesis suggesting that no significant difference in achievement existed between the learners exposed to Vee diagramming and those not so exposed could not be rejected (t-calc < t-crit), although the post-test results of the learners exposed to Vee diagramming were slightly better than the

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pre-test results. Also, the null hypothesis suggesting that no significant difference in achievement existed between groups based on language and gender could not be rejected.

In conclusion, the major findings and implications for curriculum development and instruction are highlighted. Also, the need for teachers to keep abreast of recent developments of exemplary instructional practices is recommended.

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KEY WORDS

- South Africa
- Primary school
- Grade seven
- Misconceptions
- Learners' understanding
- Vee diagramming
- Concept mapping
- Force
- Exemplary instruction
- Constructivism
- Science

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ABBREVIATIONS

GAT	General Ability Test
COFT	Concept of Force Test
PAT	Physics Achievement Test
SI	Student Interview
SQ	Student Questionnaire
OBE	Outcomes Based Education
E	Experimental Group
C_1	Control Group one
C_2	Control Group two
KR_{21}	Kuder Richardson formula – 21
STAP	Science Through Application Project
SI	Scientific Index
S_1	Student one
S_2	Student two
S_3	Student three
S_4	Student four
S_5	Student five
S_6	Student six
N	Number of learners
M	Mean
SD	Standard Deviation
USA	United States of America

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CHAPTER 1
INTRODUCTION

1.1 Introduction

South Africa is one of most geographically varied countries on the African continent. It is located on the southern tip of Africa. It is boarded by the Atlantic Ocean on the west and the Indian Ocean on the south and east. South Africa's population of 40 million is three quarters black (African), and about 15% white (European), with the remaining ten percent comprised of people of mixed white, Asian and black descent. The African majority is composed of many different ethnic groups, the largest of which are the Zulus, Xhosa, Tswana and Bapedi. Until 1990, the country's racial divisions were harshly enforced as part of the former government's official policy of Apartheid.

According to Keto (1990: 22) the way of life of the countries from which white South Africans sprang are Dutch and English in nature. The first school was established on the West Coast in 1656 for slaves, but had a very short lifespan as the slaves did not appreciate education. The central concern of this chapter is on education, starting from the pre-colonial era. During this era the focus was on traditional and religious education. The Dutch and British education systems implemented in South Africa had no regard or interest for the indigenous people of South Africa (Ritchie, 1918: 10). It was a system that was based on political decisions.

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The accession of the National Party to power in 1948 and the promulgation of apartheid laws nearly paralyzed the social and educational life of a significant percentage of the South African population. In 1953 segregated and inferior schooling was legislated for the Africans, Coloureds in 1963; and for the Indians in 1965. This policy provided an ideological cornerstone for racial segregation, economic exploitation and political oppression of these groups. The classic notion of apartheid education articulated by Verwoerd in 1953 was that education must train and teach people in accordance with their opportunities in life according to the spheres in which they live (Nkomo, 1990: 1).

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According to Cross and Chisholm (1990: 45), blacks were seen by whites as "hewers of wood and drawers of water". Education was used as an instrument to ensure white domination over blacks. As Nkomo (1990) further argued, the main objective of apartheid education was not just for blacks to accept the social relations of apartheid as natural but to promote black intellectual underdevelopment by minimizing the allocation of educational resources for blacks while maximizing it for whites. The effects of these practices were: high attrition rates, high failure rates, high illiteracy rates and alienation from the schooling process among blacks. The state spent five times more on a white child than on a black child. The teacher-child ratio for whites was 1:15 as opposed to 1:42 for blacks. Blacks attended schools that were under-resourced, overcrowded and poorly constructed, as opposed to whites whose schools became increasingly under-utilized. Historically the training of black teachers has been abysmally poor resulting in high failure rates and poor instruction and performance. The declaration by President De Klerk in 1994 that apartheid was dead, resulted in the revocation of all apartheid laws and unification of the 19 separate departments of education into one. In addition, a new curriculum known as the Outcomes-based Education (OBE) Curriculum 2005 was implemented, coupled with the redistribution of resources to disadvantaged schools and improvement of the teacher workforce in black schools (Nkomo, 1990).

The political, economic and social conditions created by the apartheid system had serious implications for the teaching of science to black learners. The science programmes in the schools were based on observation and conceptual development (Browne, 1991). The curriculum was mainly in the form of rote learning and an overemphasis was given to factual knowledge. It was a curriculum that was characterized by recitation, memorization and regurgitation. It demanded no creativity from the learners; instead it was a routine mechanical task or a rote listing of fact. It also involved the study of science removed from its practical application. The science programmes implemented in schools was dry and uninteresting. Although apartheid laws have now been abrogated, their negative effects on schooling and science education will remain for a long time to come.

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1.2 Background to this Study

The educational system implemented by the apartheid regime was characterized by rote learning, where learners were seen as passive individuals or empty vessels to be filled. It was a system in which learners were largely dependent on their teachers for information. The teachers used the chalk and talk method and lectured their notes most of the time to the learners. In such a context, very little opportunity existed for learners to take responsibility for their own learning. Ausubel (1968) refers to this type of instruction as shallow learning that discredits education and hence should be terminated. The old curriculum could not fulfill the aspirations of the society; it resulted in serious dropout rates, high failure rates, and illiteracy was the order of the day. Teachers believed they could transfer knowledge intact from their minds into the minds of the learners. The curriculum did not take cognizance of the learners' voices in the classroom and it was examination driven. The effectiveness of this learning programme was measured by the grades the learners obtained. The schools were forced to limit the enrollment rates of learners who wanted to study science at school because of their limitations to resources and the lack of materials and laboratory equipment. All this led to the belief that science was a relatively difficult subject and that only a small proportion of learners with special aptitudes could do science (Lewin, 1992).

The apartheid system of government has contributed significantly to the present economic stagnation, high unemployment rate especially among the less skilled blacks and an overall increase of economic dependence of the whole country on the more developed economies. In other words, science education has not been able to contribute significantly to technological development of the country (Lewin, 1992). It is a well known fact that science education plays an important role in the growth of science and technology which provide the driving force for socio-economic development and improvement of the quality of life for a given society. Science education aims at providing students with a wide range of knowledge and skills and to prepare them for careers in science and technology. It also contributes significantly to the development of scientifically and technologically literate communities.

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The new OBE curriculum aims at replacing the old teacher-centered approach (which encourages the memorization of facts to pass a certain public examination) with one that construes the learner - not as an "empty vessel" to be filled - but as an active individual interacting and constructing experience with diverse phenomena. The heart of the OBE curriculum has been to bring about educational change that provides equity in terms of education provision as well as promoting more balanced views by developing learners' critical thinking powers and their problem solving abilities. The goal of the education policy is that all people be granted the opportunity to develop their potential to the full whether by means of formal or non-formal schooling. Hence, the new OBE curriculum is learner centered and success-orientated. It places a great premium on:

1) The learner and his/her needs.
2) Human diversity.
3) Participatory, democratic decision making in education.
4) Encouraging learners to achieve their full potential (i.e., different levels according to individual ability).
5) The need for all stakeholders (community, parents, teacher, learners) to share in the responsibility of learning, guided by the principle that "success breeds further success" (Outcomes Based Education Policy Document, 1999, 7)

It is against the background of the history of education sketched above and current emphasis that this study was carried out.

1.3 Problem Statement

The topic of the study, force, is a part of the prescribed interim curriculum for grade seven. It is a concept that research has shown to have evinced all kinds of misconceptions, and alternative worldviews among learners (Ogunniyi, 1999), e.g. students' belief that motion implies force (Clement, 1982). The concept of force is seen

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as a complex cluster of related ideas rather than separate entities. Also, research has shown that the scientific concept of force is incompatible with the alternative conceptions held by the learners (Dekker and Thijs, 1998). Learners tend to use the commonsensical and intuitive notion of force rather than the uncommon way the concept is construed in science. Hence, the conflict that results from the incompatibility of the two distinct viewpoints is a matter warranting a closer consideration. But before examining this subject more closely, it is apposite to explore briefly a number of related issues.

Poole (1995), a conceptual relativist, claims that concepts are socially constructed. To him, concepts determine the world rather than the reverse. Hence, creating concepts e.g. Unicorn, Santa Clause or Devil does not imply that these phenomena exist or do not exist but the meanings surrounding them can be apprehended when articulated within a given context or expressed within a worldview. In other words, science is a social activity and scientific concepts do not exist in a vacuum (Solomon, 1987; Ogunniyi, 1987, 1988). According to Kuhn (1970) science thrives within the paradigm created and sustained by the activities of the scientific community. A paradigm (which consists of facts, laws, theories accepted practices, etc.) is the product of spirited efforts by members of the scientific community to test, confirm or falsify the claims of scientific findings. Therefore, a paradigm stands or falls on the basis of empirical evidence (Popper, 1965). Ultimately, the paradigm is simplified, translated and adapted to various levels of sophistication, which appear in textbooks, journals, magazines etc., for public consumption. Schools science is one of the simplified versions of this paradigm and the tests based on it are rendered in such a way that could inspire a student to want to study science. By the same token, a science textbook should be well illustrated and written in a simple readable language to enhance comprehension. Otherwise, learners might develop a negative attitude towards science or hold only alternative conceptions that hamper his/her study of science. Alternative conceptions - also called misconceptions, preconceptions, children's science, etc. (e.g. see Driver and Erickson, 1983) - are normally based on beliefs, intuitive and commonsensical notions about diverse natural phenomena. Two issues about alternative conceptions worthy of attention are:

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i. Why do such beliefs or conceptions exist at all?

ii. What is the actual nature of the beliefs or conceptions?

Poole (1995) describes Temples' contribution to practice in science education in terms of how one's belief is profoundly affected by the way he/she was brought up and this of course, might have nothing to do with whether or not such a belief is true or false. He contends further that the constructivist notion that people construct their own reality sounds linguistically odd because it seems to suggest that an objective world exists because somebody thinks it up. He argues further that the idea implying that pupils construct their own reality and meaning only if they are under pressure is rather untenable.

According to Adams (1999) pupils' beliefs about the world influence their study of science. To him, pupils from various cultural backgrounds hold different explanations about the phenomena encountered in science, which might contradict their sense experience. For instance, the scientific concept of "force" often proves difficult to most learners because it is used in science quite differently from the way it is used in their everyday language in that their understanding is based on their own conceptual everyday experience of strength, stress, pressure, power, etc. According to Ogunniyi (2002) the everyday understanding of the concept of force becomes the very barrier to the scientifically valid worldview. For example, students come into the science class with already well-formulated ideas or firm beliefs about natural phenomena quite different from that of school science. The nature of students' alternative conceptions of diverse natural phenomena otherwise called "alternative frameworks" have been found to be critical to their performance in school science (Driver and Erickson, 1983; Ogunniyi 1987, 1998, 1999). In his theory on collateral learning Jegede (1995a) argues that learners' alternative worldviews tend to co-exist with the scientific worldview without necessarily interfering with each other. Vygotsky (1978) believes that children learn scientific concepts out of "tension" between their everyday notions and adult concepts. Presented with a pre-formed concept from the adult world, the child will only memorize

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what the adult says about the idea. Before the child assimilates the new idea into his/her cognitive structure he/she links it with the previously known idea and its meaning.

Rollnick and Rutherford (1998) looked at the relationship between scientific discourse in the community and scientific discourse in the school and explained that social practice of science is interpreted through specialized grammar and text structure. According to them, scientific terminology is different from the everyday language utilized by the learner in society. This creates difficulty for the learner as he/she tries to make sense of school science. According to Ogunniyi (1986) the problem here is that the language of instruction, which is supposed to convey information to the learners, becomes the very barrier to their understanding of science. The concepts of science, which constitute the language of science, provide the essential meanings, which the learners link to their everyday language. Ogunniyi (1988) suggests further that a bridge needs to be built between the personal and creative language of the learner and the formal and impersonal language of school science.

Taken the above comments into consideration, the study focuses on determining grade seven learners' understanding of force. Also, the study attempts to ameliorate the learners' misconceptions through the use of Vee diagramming, an instructional tool developed by Gowin in 1984 (Ebenezer and Connor, 1998). Vee diagramming is essentially based on the constructivists' view of the teaching and learning process, particularly the work of Ausubel. According to Ausubel (1968) the most important thing to consider in the instructional process is to determine where the learner is before exposing him/her to new learning materials. I will elaborate on this in the next section.

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1.4 Theoretical Framework

As indicated earlier, this study draws inspiration from the constructivists' perspective of learning as espoused by Ausubel (1968), Driver and Erickson (1983), Osborne and Wittrock (1985), Aikenhead and Jegede (1999) and Ogunniyi (1995 and 2002).

The underlying tenets of constructivism are that:

1) Each learner constructs his/her learning based on his/her previous interaction with the environment.
2) The learner uses his/her conceptual framework to explore and interpret natural phenomena.
3) Instruction should start where learners are before taking them forward.

According to Driver and Erickson (1983), a conceptual framework is a mental organization imposed by an individual to interpret experience with natural phenomena. Cognitive theory, which underpins constructivism, is concerned with the changes in a learner's understanding that results in learning. According to the constructivists' perspectives, learners are active beings responsible for the generation and construction of their own knowledge. The constructivists do not see the mind of the learner as a "tabula rasa" or a blank sheet to be written on by the teacher. Rather, they believe that learners have their own pre-conceptions about phenomena which help them to make sense of the world they live in. Poole (1995) cites Driver as defining constructivism in terms of:

> The perspective whereby individuals, through their own mental activity experienced with the environment and social interactions, progressively build up and restructure their schemas of the world around them (p.45).

Phrases like "constructing meaning", "constructing knowledge", "constructing our world", "constructing reality" and making sense of the world are endemic to the constructivists' idea of learning. According to Adams (1999), research in the 1960s and 1970s focused on personal constructivism. However, from the 1980s this idea was

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broadened to socio-cultural constructivism, i.e. individuals construct ideas based on experiences derived from their socio-cultural environment. He argues further that to ignore such socio-culturally based experience is to block a learner's opportunity to learn in a meaningful way or for him/her to construe science as an artificial activity with little or no value to his/her life outside the school environment.

Osborne and Wittrock (1985) argue that:

> Children develop ideas about their world, develop meaning for words used in science and develop strategies to obtain explanations for how and why things behave as they do, long before they are finally taught in science. (p.25)

As started earlier, the ideas and beliefs that learners hold are referred to as "alternative frameworks", "alternative conceptions", and "children's science", etc. (Driver and Erickson, 1983; White, 1991).

Poole (1995) adds that, within the constructivists' paradigm, instruction in science should:

i. Start at the level where learners are with respect to a given concept,
ii. Emphasize active learning, rather than rote learning using dialogue and arguments;
iii. Emphasize the importance of the social milieu within which learning takes place. (Poole, 1995: 45)

However, as stated earlier, learning does not take place in a vacuum and classroom practice is highly influenced by both the social and cultural aspects of thc child's life. Also, as alluded to earlier, ideas that a learner constructs or the meaning he/she derives from his/her socio-cultural environment may not be scientifically valid. This issue marks a good point of departure to consider how the study has drawn inspiration from Ausubel's learning theory on which concept mapping and Vee diagramming is based.

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1.4.1 Ausubel's "Assimilation Theory of Learning"

According to Ausubel (1968) the gap between a learner's knowledge and what he/she ought to know is real. Therefore, when he/she experiences a sort of cognitive disequilibrium, the task of the teacher is to help the learner link what he/she already knows with what he/she ought to know. Ausubel believes that a learner possesses certain knowledge in his/her cognitive structure. He regards this generalized knowledge as subsumers, which act as anchors for new experiences. To him these subsumers are critical for linking what is known with new materials to be learned. In the absence of such subsumers, which act as anchors to new learning, it is the teacher's task to substitute advance organizers.

According to Ausubel (1968) advance organizers are broad but comprehensive statements, which help to link the new material with what the learner has already learned. It is this linking of the two forms of conceptions i.e., the learners and school science, which Ausubel calls meaningful learning (Ogunniyi, 1986). Further, Ausubel contrasts meaningful learning with rote learning. According to Ausubel, rote learning involves mainly the memorization of concepts without a clear and an in-depth understanding of that concept. To him, in the final analysis, learning is both personal and idiosyncratic. Hence, the task of the teacher is to ensure that the learner is exposed to a setting that would facilitate his/her linking it to what is taught with the way he/she learns. To ignore this principle is to turn learning into a routine, mechanistic activity devoid of meaning. To facilitate the learning of science, a number of attempts have been made to develop various instructional aids or procedures. A popular attempt in this regard was the one developed by Gowin in 1984 called Vee diagramming (Ebenezer and Connor, 1998). Vee diagramming serves as a visual lens for promoting new knowledge production and understanding. According to Novak and Gowin (1984), meaningful learning involves the assimilation of new ideas and knowledge and the proposition into existing structures. Vee diagramming is a heuristic device used to organize scientific concepts and ideas. It can be used critically to illustrate ideas regarding the nature of knowledge and the process by which new knowledge is developed into a scientific investigation (Ebenezer and

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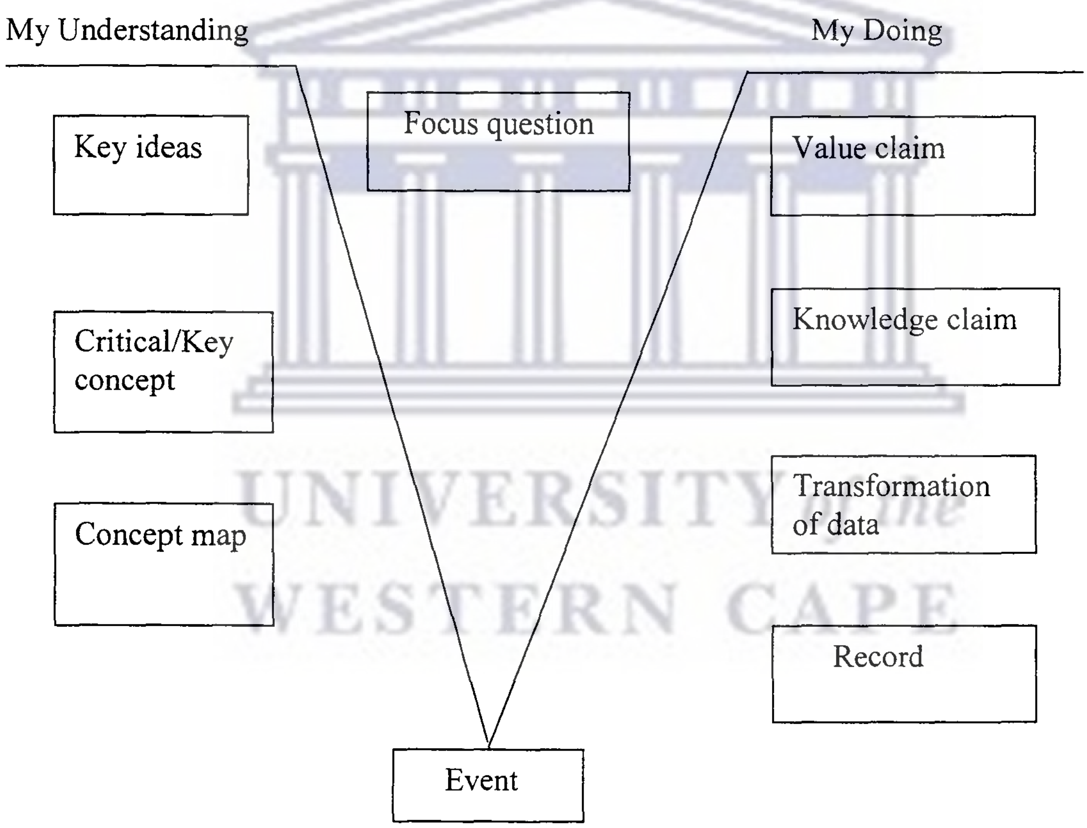
Connor, 1998). Basically a Vee diagram consists of two main parts: 1) the development of a concept map (see figure 1.1). As can be seen in figure 1.1, the left side of the Vee diagram shows the key ideas which will guide the actual study and the concept map which organizes the concepts to be learned from the general to the specific. This is what Novak and Gowin (1984) call "my understanding" or "my knowledge". The event at the intersect of "my understanding" and "my doing" is the actual problem or task to be investigated. On the right side of the Vee diagram is what they call "my doing". The "my doing" part of the Vee diagram describes what is observed during the event, collection of data and conclusions reached on the basis of the observations.

Figure 1.1: Diagrammatic Representation of a Vee Diagram



Source: Ebenezer and Connor (1998: 62)

Hence, to learn a new concept implies first the need to organize the new concept in an orderly way and then to follow the new idea in an orderly way with activities that make

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that knowledge experiential and authentic, i.e. a sort of "learning by doing". Hence, Vee diagramming includes and incorporates a concept map into the development of a plan for scientific inquiry. In line with Ausubel's theory of learning, knowledge is assumed to be hierarchical and Vee diagramming shows how a scientist's conceptual knowledge may be used as a lens to observe a scientific inquiry. The concept map part of Vee diagramming identifies the connections between the ideas which the student already has, and then connects such ideas with new ideas. It also helps to organize the information in a logical order while leaving room for future information to be included. It is a technique which provides the teacher with opportunities to see what the learner already knows before embarking on instruction. It is also a useful tool for reviewing what has been taught or for introducing what is to be learned. In view of this it is hoped that Vee diagramming would prove to be useful in ameliorating the incorrect conceptions about forces that are held by the learners involved in this study.

1.5 Purpose of the Study

The study aimed at determining (paper and pencil) conceptions of force held by the grade seven learners. It examined how certain socio-cultural factors such as language, gender and interest influence their understanding. It also explored how concept mapping and Vee-diagramming might serve as useful teaching tools in facilitating the learners' conceptions of force. In pursuance of this purpose, answers were sought to the following questions:

i. What are the subjects' written conceptual understandings of force and how scientifically valid are such understandings?

ii. Are the subjects' understandings of force influenced by such socio-cultural factors as sex, language or interest in science?

iii. What is the effect of concept mapping and Vee diagramming in improving the learners' performance on a test of understanding of force?

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1.6 Research Hypothesis

The following null hypotheses were posited for testing:

1) The subjects do not hold scientifically valid conceptions of force, as measured by the concept of force test.
2) There is no relationship between the subjects' sex, language or interest in science and their performance on a test of understanding of force.
3) There will be no difference in the understanding of force held by the subjects exposed to a concept mapping and Vee diagramming treatment approach and those exposed to a traditional lecture/expository approach or treatment.

1.7 Scope of the Study

This study sought to determine a sample of grade seven learners conceptual understanding on the concept of force, and the use of concept mapping and Vee diagramming to ameliorate the incorrect conceptions held by the learners. To achieve this objective specific instrument in the form of an achievement test, questionnaires, interviews and class observations were used to asses the learners' conceptions of the concept of force. As a small scale study no generalization would be made beyond the two schools involved in the study.

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Significance of the Study

It is hoped that this study will provide useful information regarding:

1) The alternative conceptions held by the subjects about forces and the problems they encounter on the concept.
2) Possible influence of certain socio-cultural factors such as sex, language, etc on the subjects' understanding of force.
3) The effectiveness or otherwise of concept mapping and Vee diagramming in enhancing the subjects' understanding of forces.

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1.9 Limitations of the Study

The two major constraints in this research were time and finance. Due to these factors the study was limited to only two schools for two weeks of treatment in a specified area. The same constraint also limited the sample size to 75 learners only.

1.10 Definitions of Terms

Force: Refers to the Newtonian definition of the concept which is the product of mass and acceleration (Brink and Jones, 1986: 29).

Alternative conception: Also referred to as children's science, this is the learner's explanation of scientific phenomena based on his/her interaction with the environment or his experience (Erickson and Driver, 1983:41).

Meaningful learning: Meaningful learning is the incorporation of a new concept into the existing cognitive structure of the learner. The existing concept acts as an anchor for the new idea (Odom and Kelly, 1998: 33).

Rote learning: This involves mainly memorization of concepts without a clear and in-depth understanding of that concept. It is related to the cognitive structure but only in a verbatim fashion that does not result in the acquisition of any meaning (Ausubel, 1968: 41).

Vee diagramming: This is a heuristic device used to organize scientific concepts and ideas. It includes key ideas, concept labels and a concept map on the left-hand side entitled "my understanding" while on the right hand side it includes the actual investigation, record of data, transformation of data (if necessary), the actual findings or knowledge claims and value claims, i.e. the application of the finding. A concept map helps the educators to identify the existing knowledge of his/her learner while the "my doing" part illustrates critical ideas regarding the nature of knowledge and the process by

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which new knowledge is developed in a scientific investigation (Ebenezer and Connor, 1998: 58).

Concept Mapping: It is a schematic device that represents a hierarchical set of concepts that are linked with propositions to create conceptual meaning. In other words, a concept map is a semantic network of concepts and related presuppositions. Concepts are linked with words or phrases that show the relationship among them. (Heinz-Fry and Novak, 1990: 461).

1.11 Summary

This chapter discusses the historical context of education in terms of political, economic and social conditions created by the apartheid system. The problem statement, with respect to worldwide difficulties experienced when attempting to teach the concept of force, the theoretical framework, based on socio-cultural constructivism, scope, significance and purpose of the study are dealt with. Also, its limitations and research hypothesis are stated and concludes with the definitions of the respective terms.

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CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

As indicated in chapter 1, this study seeks to determine grade seven learners' conceptual understanding of the Newtonian concept of force. It attempts to correct their incorrect conceptions of the concept through the use of a Vee diagram. The emphasis is not on replacing the learners' incorrect conceptions but to help them integrate new knowledge into their existent cognitive structure. A lot of research has been done in the area of force at high school and tertiary levels (e.g. Clement, 1982; Halloun and Hestenes, 1985; Thijs, 1992; Thijs, Dekker and Smith, 1993) but very little has been done in South Africa at the primary school level. A review of the literature shows that, though learners do hold some valid ideas about the concept of force, their overall understanding of the concept is inadequate (Ogunniyi and Fakudze, 2002; Dekker and Thijs, 1998).

2.2 Theoretical Consideration

As pointed out in chapter 1, this study is underpinned by the constructivists epistemology as espoused by a number of scholars (e.g. Ogunniyi, 1995, 2002; Jegede, 1995a; Vygotsky, 1978; Ausubel, 1968; Ausubel, Hunesian and Novak 1978; Novak and Gowin, 1984; Aikenhead and Jegede, 1999; Driver and Erickson, 1983 etc.). According to Fensham, Gunstone and White (1994) constructivism is as old as tradition. To them the theory originated in the days of Socrates and Plato. Even today, traces of the Socratic way of teaching are still evident in our classroom practice. They argue further that Socrates taught mostly by insightful questioning that helped others reduce their fragmentary knowledge of phenomena into a meaningful and comprehensive knowledge of such phenomena. The theory of constructivism has emerged over the years as scholars made attempts to understand how learners learn and how best to enhance such learning. Montessori, Piaget, Brunner, Vygotsky, and others provide historical precedents for constructivism. These scholars believe that rational inquiry is necessary to shape

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learning. It is a view that is not based on a positivist psychological theory of learning which assumes that the mind of the learner is like an empty vessel to be filled with knowledge. According to Driver and Erickson (1983), the strength of this theory lies in the fact that, the life and mind of an individual learner is a dynamic reality, i.e. intelligence is a real and constructive activity.

Most of the first half of the 20th century was dominated by behaviourism, a positivistic perspective of learning. However, before the end of that century, constructivism, precursor of cognitivism had gained supremacy over behaviourism as a theory of learning. The shift from behaviourism to cognitivism was inevitable in the face of copious examples of ineffective curricular materials and instructional strategies based on the former. Even in the hay day of behaviourism, a lot of criticism had been made by cognitivists of the erroneous idea that human learning could be compared to an input-output notion of a mechanistic process. Socio-cultural constructivism an offshoot of cognitivism, construes learning as a socio-cultural activity in which both the teacher and the learner play active roles. Socio-cultural constructivists contend that learners do not enter the science classroom with empty minds but hold intuitive ideas derived from their cultural setting. Hence, their perceptions of reality are moderated by knowledge gained from experience (Ogunniyi, 1995, 2002; Driver and Erickson, 1983).

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To most socio-cultural constructivists learning does not take place in a vacuum (Ogunniyi, 1995) but the ideas developed by learners are influenced by their culture (Brunner, 1996). Piaget (cited by McNally, 1973) coined the term intellectual structure which is what the learner has for his interpretation and solutions of problems. It also changes as a result of interaction, maturation and experience.

Modification of the cognitive structure occurs when the learner is faced with a situation where the old idea and habits cannot cope with the new experience, the learner is then forced to consider viable alternatives that can help him/her to reconstruct his/her experience in order to deal with the new situation. In other words, a new experience might create cognitive conflict that ultimately results in an action that leads to successful

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solution to the new situation or problem. This view of learning also forms the backbone to Brunner's theory of discovery learning. His theory serves as a base for students' interaction with the environment by exploring and manipulating objects by wrestling with questions and controversies or performing experiments to find solutions to the conflict involved by the new experience (Ogunniyi, 1988).

To Brunner, it is easier for learners to remember concepts that they have discovered through experience than what they are told. It is even more successful when the new concept is integrated into the existing knowledge (Ausubel, 1968; Ausubel, Hanesian and Novak, 1978; Rollnick and Rutherford, 1996). However, there is now a growing interest in the notion that learners invent knowledge based on their interpretation of sensory impressions which influence the way in which they respond to, and understand the connotative knowledge present in the science classroom (Driver and Erickson, 1983). It is through experience with the environment and social interaction that learners build up their own ideas of the world around them.

Making sense of the world is endemic to the constructivist; and the learning environment (classroom) should not be different from the atmosphere that exists in society. To the constructivist, the attitude the learner develops at home should not be too different from that at school. The contention is that, if this is ignored in the learning process, it might result in the learner rejecting the school experience. Within the constructivist paradigm, the teacher is portrayed as a midwife in the "birth of understanding" rather than the mechanics of knowledge transfer.

Vygotsky (1978) argues that learners should be given some degree of freedom which allows them to play in a meaningful and orderly way. As children interact through play they learn to be creative, to share tasks, improve their language, discuss and develop leadership skills. He argues further that the social setting in which learning takes place has profound influence on the learner's growth of knowledge and understanding. Hence the learner should be allowed to communicate in his/her symbolic language inside the classroom, because the classroom culture has intensified effects on the teaching and

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learning process. The implication there is that learners should be allowed to express their views about the subject matter being examined in a science lesson. However, if they are unable to express their viewpoints they tend to switch off, so to speak, and to engage their intellectual interest in something else.

2.3 Why Learners Experience Difficulty with the Newtonian Concept of Force

Although force and its associated concepts such as mass, weight and gravity is an integral component of the school science curriculum, many learners detest and shun these concepts because they perceive them as very difficult to learn (Dekker and Thijs, 1998). Ample evidence also abounds to demonstrate that many learners perform poorly on force (Adams, 2003; Ogunniyi and Fadkudze, 2002; Gunstone and Watts, 1985). The abstract nature of this concept has led these scholars and many others to suggest a link between conceptual understanding and reasoning abilities. The tandem of reasoning abilities and pre-existing knowledge also appears to influence student understanding of science concepts and the development of alternative conceptions.

Inspection of textbooks shows that force is taught at different grade levels. Drawings and demonstrations with pushing, pulling and kicking objects are used by most textbook authors to rationalize and explain force. As a result, teachers use pushing and pulling at all grade levels to explain the concept to learners. Although the earths downward force is the product of mass and acceleration due to gravity ($F = ma$), learners tend not to use it in their explanations. These concepts (pushing/pulling) have been shown to be the subject of alternative conceptions (Ogunniyi and Fadkudze, 2002; Adams, 2003). Research has also shown that the scientific concept of force is incompatible with the alternative conceptions that learners hold (Dekker and Thijs, 1998). The commonly held alternative conception of force among learners is that motion implies force (Gunstone, 1988). The concept is seen as a complex cluster of related ideas rather than separable entities. The knowledge that learners hold about force is possibly best described as a slogan or a set of laws, rules and procedures memorized for examination purposes. Further, research has shown that the scientific explanation of force does not relate to real life issues, events and

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phenomena (Dekker and Thijs, 1998). Other studies have shown that learners use everyday experiences and explanations to define force. For example, some learners refer to force as strength, power, masculinity, etc. (see Ogunniyi and Fadkudze, 2002; Adams, 2003).

Textbook authors do not always take cognizance of the learning difficulties or linguistic inadequacies facing learners. Learners have experiences with force in their daily lives and know what happens when they push, pull, kick or throw objects of different sizes and shapes around. According to Shepardson and Moje (1994), learners come to formal science classrooms with ideas derived from these experiences about scientific phenomena. As a result, learners may observe the same phenomena, but their prior ideas affect the observations they make and the meaning they construct (Jegede, 1995). According to Shepardson and Moje (1994), learners often attend to what is expected rather than to what is present and to differences rather than similarities. For example, most learners expect heavier objects to fall faster to the ground then lighter objects, yet in the science classroom all objects fall to the ground at the same speed.

Because learners continuously develop and organize their ideas through observations, they often accept more than one explanation for the observed event (Adams, 2003). Consequently learners may perceive a science demonstration from a perspective that differs from the teacher and scientists. The difference in perception constrains a learner's ability to relate other scientific understandings to the phenomena observed. According to Ogunniyi (2002) learners' everyday understanding and usage of the concept may be the very barrier that blocks their way to the scientific understanding of the concept. This is further compounded by the belief teachers adhere to, namely that knowledge can be transferred intact from their minds to the minds of the children. Both children and adults often use the term force very loosely in their everyday lives and perhaps that is what is appropriate in that context. However, in the science classroom, it is the responsibility of the teacher to help the learners make a clear distinction between the way the concepts are used outside the school and in a science lesson. In a study conducted by Ogunniyi and Fakudze (2002) it was found that the concept of force had no equivalent terms or

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concepts in the mother tongue of the learners. In this regard, the concept of force, as treated in the science class, tends to gain a higher level of abstraction and learners are left with little or no option then to memorize the teachers' notes for examination purposes.

2.4 Socio-Cultural and Psychological Issues in Science Education

According to Adams (1999) learners that come from a traditional background have an anthropomorphic view about nature as opposed to the mechanistic view of nature indicative of western science. In a traditional context people invented their own concepts, which enabled them to impose some sort of meaning on the world (Poole, 1995). Unlike the scientists, whose world is mechanistic and impersonal, the learner's world is personal and anthropomorphic (Ogunniyi, 1988). There is no common frame of reference between the scientific and the traditional views of diverse phenomena including force. As indicated in chapter 1, learners' ideas about force are largely based on cultural beliefs and their own experience. However, learners' minds are not culture free (Brunner, 1996, Ogunniyi, 1988, 1995, 2001; Jegede, 1995a; Aikenhead, 1996). It is for the same reason that this review examines briefly the issue of enculturation in the learning of school science.

Goa (1998) asserts that the teaching and learning of school science is context dependent. Both the teacher and the learner hold distinctive belief systems and values regarding school science. He argues further that culture is a contextual lens through which people view and understand the world and which directly influences their cognitive processes and understanding of science. Learners construct their own knowledge and explanations about natural phenomena. They also develop their own views of the natural world (Adams, 1999). The knowledge and information learners have regarding school science are a direct result of socio-cultural influences (Ogunniyi, 1988, 1995; Erickson and Driver, 1983 and Adams, 1999). In this regard, the main objective of science education is to shape the existing knowledge into a more scientifically valid knowledge. According to Adams (1999), there is a growing interest among science educators that learners' belief

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about science are influenced by the worldviews commonly held in their socio-cultural environments. He cited Proper and others as asserting that an individual's worldview consists of ideas that he/she holds consciously or unconsciously about the basic nature of reality and how one construes it. According to Fakudze (2002) different cultural groups hold different worldview presuppositions that are distinctive from that of school science. Adams (1999) argues that there is no doubt that a clear distinction exists between western and non-western cultures. He cited Aikenhead as stating that when school science is in total harmony with the learner's worldview this will enhance the process of enculturation of science. Science as an aspect of culture does not embrace all aspects of culture and hence uses only strategies amendable to empirical testability. Culture, on the other hand, embraces human activities which, strictly speaking, are outside the realm of experimentation. According to Brunner (1996: 23):

> Culture is a way of life where reality is represented by a symbolism shared by members of a community in which a technological-social way of life is both organized and constructed in terms of that symbolism. The symbolism is not only shared by that community but is passed on to succeeding generations, by virtue of this transmission continues to maintain the cultures identity and way of life.

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Despite the distinction between science and the general culture, there seems to be a direct commutation between the nature of the mind and the nature of culture. The meaning of any fact is relative to the frame of reference in terms of which it is construed. Let us take the Robben Island in South Africa as an example. Some remember it as an episode in the history of South African imperialism; to others it is regarded as a monumental step towards freedom and independence, while still others might remember it simply as a prison or a place of torture and unbridled dehumanization. To fully understand what something means requires some awareness of the alternative meanings that are attached to that subject matter. Understanding something in one way does not preclude understanding it in other ways. Interpretation of meaning reflects the culture's authoritative ways of constructing reality. Nothing is culture free; neither are individuals

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simply mirrors of their culture (Ogunniyi, 1988). According to Ausubel (1968), the abstraction, generalization and categorization of meaning are already abstracted for the young by their cultural forbearers. Learning and thinking are always situated in a cultural context and dependent of cultural resources.

Education is a major embodiment of a culture's way of life and not simply a preparation for it (Brunner, 1996). Tharp (1989) asserts that the exclusion of culture from the science classroom has a fallacious effect on student achievements. According to Hurd (1998), ignoring the learners' cultural worldviews has resulted in learners seeing science as nothing but a collection of "dead facts" for which they show no appreciation. Ogunniyi cited by Adams (1999) asserts that science should not be seen as a collocation of facts but as an attempt by human beings to organize their experiences as a meaningful system of description, explanation and prediction. When science is presented as a catalogue of facts to be committed to memory then learners are tempted to regard it as such. Consequently, all they do is to memorize what is given to them, regurgitate this in examinations and forget it as quickly as possible. This type of instruction is unfruitful and discredits education because it makes the students passive recipients of other peoples' ideas rather than becoming active generators of knowledge. Students may pass examinations but they may not be able to use a concept or know its relevance in their everyday experiences. This implies they need to be exposed on how to use conceptual tools in authentic activities. They require more than abstract concepts and self-contained examples that turn them into "parrots" rather than creative thinkers.

Culture has many external implications for science education. According to Meyerson (cited by Brunner, 1996) the function of collective cultural activities is to produce works that achieved an independent existence. These include the arts, sciences of a culture, institutional laws and historical structures that are conceived as the canonical versions of the past, i.e. works that give identity, pride and a sense of continuity from generation to generation. For instance, it may be inspirational if an institution has produced three Noble

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laureates in science. Such an accomplishment immediately puts a stamp of distinction on that institution and galvanizes other scientists in that institution to want to achieve the same goal. This occurs because excellence is a catalyst which creates a culture characterized by a unique form of thinking which facilitates creativity, resourcefulness and a high level of reflection which propels collective experience. In other words, all cultures and sub-cultures including science conserve their works and pass it on to the following generations (Ogunniyi, 1988; Jegede, 1995).

The question now is, how do teachers open the door of cultural liberation for learners in their classrooms and how can they encourage learners to communicate in the unique culture and symbolic language of science? It seems to me that science teachers should allow learners to relish interpretation of historical scientific events. On the other hand science teachers should endeavour to help their learners to adapt their traditional worldviews to science in order to create a sense of enduring meaning in a scientific knowledge, skills, attitudes and a distinct way of viewing the world. In his seminar on the effect of poverty on urban school learners in the USA, Kyle (2002) argues that poverty has powerful effects on how much and how we educate the young. The innate talents of learners from high poverty backgrounds are altered in the first two years of schooling. According to him, learners know less then when they entered such a school. What seems to have happened in this regard is that the education these children receive in the school or their school experience does not coincide with their life worlds. It merely succeeded in neutralizing their potential for success by destroying their native intelligence. This occurs because the learners are introduced to a form of thinking that makes them completely dependent on the teacher as the major source of knowledge. Rather than work with their hands, converse with their mates and tackle problems collectively, they are taught to compete with each other and as much as possible to act independently of each other.

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2.5 Conceptual Difficulties and Conceptual Development

Humans live in a world of concepts rather than objects, events and situations. Concepts are derived from bodies of knowledge and propositions that make possible the invention of language with relatively uniform meaning. Concepts act as anchoring foci for the assimilation and discovering of new knowledge (Ausubel, 1968; Ausubel, Hunesian and Novak, 1978). It is one thing to acquire a concept but quite another to apply it in a meaningful way to one's environment. Cognitive utilization of existing concepts is exemplified in a manner in which reception occurs.

According to Vygotsky (1978), children learn scientific concepts out of tension between their everyday notion and adult concepts. Presented with a pre-formed concept from the adult, the child will only memorize what the adult says about the idea. This is because the generalization and differentiation of a concept have already been abstracted for the learner by his/her cultural forbears (Ausubel, 1968; Ausubel and others1978). This results in learners entering a science classroom with all kinds of alternative conceptions. According to Dekker and Thijs (1998) there is no consensus in the literature about the status, nature and origin of alternative conceptions. Most of the authors resort to the notion that alternative conceptions as creative assumptions are constructed by learners to make sense of the world.

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The explanation given to concepts may not be related to the social reality or the environment of the proponents. Concepts serve as a cognitive structure that facilitate the acquisition of new material; more so in the sense of concept formation, perceptual categorization of experience, problem solving and in perceiving meaning of previously learned concepts and propositions. Ausubel (1968) portrays the most important thing to consider in the teaching and learning process is what the learner already knows. Learners will never undergo total conceptual replacement, unless they become dissatisfied with what they know (Dekker and Thijs, 1998; Gunstone and White, 2000). Postner cited by

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Chiu, Chou and Lui (2002) asserted that, in order for conceptual change to occur, four conditions of assimilation must be present:

1. The learner must be dissatisfied with what he/she knows.
2. The new conception must be intelligible.
3. The new conception must be plausible.
4. It should steer the possibilities of a fruitful research programme.

It should be the responsibility of the teacher to foster intellectual conflict through the process of border crossing (see Ogunniyi, 2002) and to provide the learners with the cognitive tools to resolve the conflict and to accommodate the new concept. Conceptual replacement is not an adequate strategy to foster intellectual growth surrounding their understanding of force. This can only be achieved if science educators can bring the science they teach in the class more closely to the cultural and traditional worldview of the learner. This objective can be achieved by using the learners' prior belief to serve as a basis for their development of the scientific view of force. This forms a point of departure to the subject of border crossing which I will discuss next.

2.6 Border Crossing

Aikenhead, cited by Fakudze and Ogunniyi (2002), considers a learners experience with school science in terms of crossing borders from his cultural worldview to that of the sub-cultures of school science. The crossing of borders from one worldview (e.g. traditional cultural) to the other (science) normally results in cognitive conflict (Ogawa, 1986). Border crossing deals with the dynamics of the process. Aikenhead (1996) and Jegede (1995) have identified different types of border crossings. However, these categories do not seem to explain the dynamics of the phenomena involved and how learners resolve the conflict.

According to Ogawa (1986) the contact between traditional and scientific worldviews results in mental conflict. However, Ogunniyi (1988, 2001) contends that, if such a

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conflict exists at all, it is only a temporary affair which is resolved by the individual through a process he called harmonious dualism. In other words, the new worldview interacts within the cognitive structure of the learner creates a form of conflict which the learner then attempts to integrate into the latter. If the knowledge cannot be assimilated it is rejected, loosely accommodated or compartmentalised to be used when occasions demand its usage. Whether or not the new information is assimilated or rejected will depend on the success of the integrating mechanism of what Ogunniyi (1988) calls the "bridge principle".

According to Ogawa cited by Ogunniyi (1995: 7):

> A scientific worldview is an abstract worldview in which nobody lives and is separated from the real world…The Japanese never lost their cultural identity when introducing western science and technology because they introduced only practical products of western science and technology never its epistemological worldview.

Another theory that has been posited to describe the phenomena of border crossing is collaterallity as espoused by Jegede (1995). Different forms of collateral learning exists namely parallel, simultaneous and secured collateral learning (see Jegede, 1995). In parallel collateral learning learners hold conflicting worldviews which do not interact and exist independent of each other. According to Jegede (cited by Ogunniyi, 1996) the scientific worldview is kept at arm's length from the scientific worldview depicted by school science. Yet learners do not reconcile the two worldviews; they use whichever worldview is appropriate at a given context. Tharp (1989) found that compatibilities between science and culture have felicitous effects in student achievement. The cognitive conflict becomes the very barrier to learners for absorbing the scientific concepts.

Many researches have shown the persistence of cultural beliefs in the face of school science (e.g. Ogunniyi, 1996; Jegede, 1995a). Today, it is well known that learners enter the classroom with all sorts of ideas which are distinctly different from the scientific worldview. Somehow, science teachers believe they can teach western science in a non-western setting. They assume that by teaching western science their students will throw

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away their traditional beliefs automatically. According to Ogunniyi (1988) science and the traditional worldviews are based on different conceptual models. However, despite the incomprehensibility between the two worldviews, ways should be found to provide a meaningful point of contact between the two. If western science can be presented in a corresponding way to the African culture, then learners will be in a better vantage to accept the scientific point of view. He attempts to show how the two worldviews can be reconciled to each other through his contiguity hypothesis.

The contiguity hypothesis is a modification of the harmonious dualism hypothesis (Ogunniyi, 1988). It embraces the notion that learners enter the classroom with relatively well formulated ideas about phenomena. According to the contiguity hypothesis, the learning process involves a series of physical, metaphysical and psychological relationship interactions which help the individual to accommodate or assimilate an experience into his/her cognitive structure. Since the student's everyday knowledge does not usually coincide with the scientific way of viewing the world he/she resolves conflicting ideas by seeking intellectual harmony or conceptual reconciliation through the process of cognitive restructuring or adaptation (Ogunniyi, 1988)

2.7 Language

According to Ausubel (1968) the capacity for inventing and acquiring language is one of the most distinctive features of human development which separates it from that of the other animals. Without a language the development and transmission of shared meanings, values and tradition would be impossible. Chomsky, cited by Brunner (1996), asserted that speech evolved from a human organ that developed independently from all other human capacities and makes it possible for humans to develop serious local languages. He argues further that something in our genomic composition makes it ostensibly possible to adapt at picking up lexico-syntactic structures of any natural language. According to Jackendoff (1994), this happens as a result of the biological functioning of the brain. His belief is that mental grammar is embryonic and part of the DNA responsible for structuring our learning faculties. He argues further that, in order for

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children to learn a language, they must construct a mental grammar on the basis of their interaction with the environment (experience) and their own innate resources. So often science teachers speak to children in a meaningless way because children have no way of mapping the signals into thoughts or even words. This causes children to lose interest in science because they cannot see the relevance of the content to be learnt, nor can they link it to their existent cognitive structures. This relates to the issue of whether or not the mental grammar of the child can be related to the mental grammar of the teacher, because the experience of a spoken language is actively constructed through the child's mental grammar. Words are psychologically distinguishable and not entirely physical.

Linguistical development is also directly related to culture. Language constitutes the elaboration of culture. Ausubel, Hunesian and Novak (1978) found that the cognitive attainment of knowledge (subject related or general) depends on verbal and other forms of symbolic languages. Learning objectives should be specified in such a way that they make evident to the student concepts to be learned, in a language that facilitates recognition by them to linkages between what they already know and the new concept to be learned.

Brunner (1996), on the other hand, asserted that language and symbolization are the direct cause of complexities in cognitive functioning. He quotes Ausubel (1968) as asserting that:

> ...once the child has succeeded in internalizing language as cognitive instrument it is possible for him to represent and systematically transform the regularities of experience with greater power and flexibility than before (Brunner, 1996: 41).

Brunner concurs with Ausubel's ideas and extends his view that understanding and discovery of ideas are completely a subverbal internal process. According to him: "...the entire substance of an idea inheres in subverbal insights" (Brunner, 1996: 35).

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The symbolic meanings of language are socially constructed rather that genetically determined, because children live in a cultural setting. Language acts as a barrier to learning because the classroom language is alien to the everyday language usage of children. According to Ogunniyi (1988) the gap between the everyday language and school science is rather broad. Vygotsky (1978) believes that the language of school science should not be different from the cultural everyday language of the learner because life is not demarcated and children should be allowed to communicate in their symbolic languages or cultural metaphors. Language ensures a form of cultural uniformity in the generic content of concepts thereby facilitating interpersonal cognitive considerations.

2.7.1 Second Language Instruction

Debates on the medium of instruction have increased in intensity in the developing world. The question that one needs to ask is, "Do languages inherited from colonialists have negative effects on science teaching and learning?" I will now look at this matter more critically in the following sections.

It is evident that a second language user is in a different psychological state from the native language learner. The first language users have already mastered the basic vocabulary and syntactical code of the language. They argue and communicate stronger than the second language users (Ausubel, 1968). According to Brunner (1996) linguistically stronger learners tend to perform better then the weaker ones. Johnson (1993) cited Cassels and Johnson who asserted that the difficulties learners experience are not just the technical language usage in science but how common everyday language is used in science. They argue further that language becomes meaningful once the learner has established representational equivalents between new technological concepts of science and the everyday language. Bernard cited by Ausubel (1968) argues that the learner approaches the second language with the mechanism of the first language already fixed in his/her thought and speech. According to Nenty (2000), experience tends to show

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that even among many people with a very good command of a second language, thought processes are still fundamentally evident in the first language. Therefore, if the use of the mother tongue as the language of instruction in the early years of education have proven advantageous then every effort should be made to introduce the concept to be taught in that language. This view on second language instruction is extended further by Collison cited by Rollnick and Rutherford (1996) who found that learners can make higher cognitive level statements in the mother tongue than English.

According to Ausubel (1968), when the language used in the science classroom sounds foreign or alien, the learner resorts to an audio-lingual approach to learning the language. The audio-lingual approach to learning a new language is an approach whereby the learner has no meaningful understanding of words used in the text and depends on pattern practice, drilling and memorized dialogue. The learner does not understand the function of the words or the total meaning of the phrases. This kind of approach is evident in our classrooms where teachers believe that the language and issues in science can be transferred intact from the mind of the teacher to that of the learner. But, as Ogunniyi (1988) has remarked, the language of science which the teacher uses in his/her classroom is foreign to the learners because the background from which he presents or expresses it to the learners does not take the cultural background of the learners into consideration. This is what Ausubel refers to as rote learning. The disadvantages of this approach are:

1) New words in a wider unfamiliar context cannot be fitted into the learned pattern.
2) The syntactical patterns cannot be recombined in different patterns to express different ideas.

Second language mastery requires the overlapping of the basic characteristically structured pattern of the language. Results of related studies in Africa on language and cognition have shown that the classroom use of language which is not the first language of the learner results into cognitive difficulties (Nenty, 2000). The language of instruction contributes significantly to the quality of academic performance of learners. Bamgbose (cited by Nenty, 2000) argues that language is without a doubt the most important factor in the learning process for the transfer of knowledge or skill as mediated through the

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spoken or written word. Also, Bird and Welford (cited by Nenty, 2000) identified two important effects of the use of second language on the academic performance of learners:

1) Intellectual hindrances are evident when children are unable to articulate the second language clearly.
2) The language will interfere in the children's understanding of questions.

Therefore, if the articulation of the language is unclear, a good understanding, internalization and acquisition of knowledge are impaired. In a study done by Rollnick and Rutherford (1996: 92) among a group of seven primary school teachers they discovered that:

> The use of vernacular languages is a powerful medium for exploring existing ideas without its use some students' alternative conceptions would remain unexposed. In addition students' written answers may conceal misconceptions which are revealed in peer discussion in the vernacular.

South Africa has 11 officially recognized languages. The majority of the student population encounters difficulties with the English language (Nenty, 2000). English is a second language and is not used frequently at home. In a recent national survey done about conceptions of force amongst learners, the results clearly show that language is one of the major problems facing our learners. The study found that, because of learners' lack of grammatical efficiency, they could not use logical connectors and conjunctions and they used words with multiple meanings. The study also showed that students could not adapt the scientific language to their everyday language because they had not even grasped or understood their own local languages (Ogunniyi and Fakudze, 2002). The results also showed that the concept of force had no local equivalents to the learners' mother tongue or his/her everyday conversational language. In some classrooms (especially high poverty areas) it is also evident that when learners are given assignments or homework to complete they tend to work without giving sufficient attention or work hard enough to answer the questions. In the schools where I taught less than 20% of the

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learners complete homework or assignments, while the rest copy the work from them. The linguistically weak learners or "I don't care learners" simply refuse to attempt to answer the questions because they are not proficient with the language.

It is important to teach science in a meaningful way such that both the concepts of science, and the language through which such concepts are presented, are understood by the students. This is because the language of the learner is the language through which he/she represents his/her reality and his social world. Therefore, the presentation of science in the classroom should be through the cultural eye of the learner. According to Rollnick and Rutherford (1996), it will aid in bridging the gap between the school and the home as separate entities. Nenty (2000) cited Cummings, Rollnick and Rutherford as stating that a mixed language approach or bilingual arrangement is worth considering because it can be advantageous in conceptual acquisition and it will aid learners in identifying different representations of the same ideas. They argue further that this approach may be problematic in the South African context because most science and technology concepts do not have equivalent translations in most of the native languages.

Their seem to exist considerable problems when it comes to constructing meaning at the interface between Zulu and English language (McNaught, 1991). The main conclusions in a study done by the Centre for Minority Education and Research include:

1) The native language is the most effective medium of instruction.
2) Transition to the second language of instruction results in an unsatisfactory development of the student's linguistic and cognitive abilities.
3) The second language proves to be advantageous if half of the student's lessons are taught in their native language.
4) A multilingual approach integrated into the curriculum gives the best results.

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2.8 Meaningful Learning

The goal of science education should be to move away from rote learning to meaningful learning (Novak and Godwin, 1984; Ausubel, 1968; Ausubel, Hunesian and Novak, 1978). However, meaningful learning does not occur automatically. It always involves appropriation in the form of accommodation, integrative reconciliation and adaptation of the cognitive structure to the new learning experience (Ogunniyi, 1988). To be meaningful, learning episodes have an internal logic which makes sense to the learner. It is for the same reason that disorganized or fragmented bits and pieces of information will not make sense to the learner. Also, as Ausubel (1968: 41) has argued, a mere verbalization of a scientific concept or generalization will result in empty verbatim experience unless the learner has prior knowledge with realities to which these verbal constructs refer. He asks, "Is there more than one valid explanation for the discrepancy between learned and remembered content and how does meaningful learning differ from rote learning?" This question certainly warrants a clear consideration.

Meaningful learning considers the psychological mechanism whereby large quantities of subject knowledge are retained in the cognitive structure over a long period of time. It occurs when the content to be learned is presented to the learner in a final form, where the learner is required to comprehend the material and to incorporate it into his/her cognitive structure so that it is available either for reproduction, related learning or problem solving at some later stage. Learners learn meaningfully if new concepts can be related to relevant concepts or existing concepts based on prior learning. This new knowledge must now interact with the learners' prior knowledge in order to restructure or modify this old cognitive structure into a new one that links the old knowledge with the new knowledge (Dekker and Thijs, 1998). According to Rollnick and Rutherford (1996), there might be some reconciliation between the old and new knowledge and sometimes the attempt at reconciliation might lead to rejection of some prior knowledge. It is an idiosyncratic process that depends on existing substructures of that concept. A prerequisite for meaningful learning to take place is the presence of a conceptual

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framework to which the new concepts can now be linked (Ausubel 1968; Ausubel, Hunesian and Novak, 1978; Novak and Godwin, 1984).

An important objective of teaching should be to present ideas and information effectively so that clear and stable unambiguous meanings emerge and are retained over a long period of time as an organised body of knowledge. This requires creativity instead of a routine mechanical task or rote listing of facts. Rote learning is ineffective and normally results in forgetting. This happens as a result of memory traces that obliterated or are replaced by similar traces in the cognitive structure that are relatively more stable. This causes a fusion of related ideas rather than the substitution of new stimulis. Vee diagramming has been found to be a useful instructional tool and learning device in the hands of both the educator and learner to bring about long term retention of what has been meaningfully learned. It can be used to asses conceptual development, to plan and to organize the learning process (Ebenezer and Connor, 1998) and hence its adaptation to the present study.

2.9 Instructional Tools Engaged in the Current Investigation

The role of instructional tools in education is gradually changing due to the growth of our psychological and pedagogical knowledge as well as technological capacities. It no longer has an evaluative function in transmitting subject matter content to students but should carry the burden of that transmission. Curriculum materials should be produced for students and not for teachers. Materials should be presented to the learner without using the teacher as a filter through which the subject content reaches the pupils (Novak, 1965). When effective instructional tools are used they reach the learner more clearly and effectively but can also be delivered on an individualized, self-paceable basis. The teacher's role should not be eliminated but channelled into the stimulation of interest. Instructional tools should be the guidance of independent study, thinking and problem solving and the direction of discussion about issues that are far too controversial or speculative. The major role of instructional tools should be to produce learning outcomes

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that are either equally as good as, or slightly better than, conventional matters (Ausubel, 1968), or to the extent to which these material facilitate meaningful learning (Ausubel, Hunesian and Novak, 1978). For the most part, instructional tools e.g. concept mapping and Vee diagramming have counted very little thus far to the goals of individualized instruction. Therefore, I will now discuss the importance and impact of Vee diagramming which embraces the two instructional tools.

2.10 Vee Diagramming

Vee diagramming developed by Gowin in 1984, is a heuristic device used to organize scientific concepts and ideas (Ebenezer and Connor, 1998). It can be used to illustrate critical ideas regarding the nature of knowledge and the process by which new knowledge is developed in a scientific investigation. According to Ebenezer and Connor (1998), when presented in a language in which the learners are proficient Vee diagramming helps learners in the following ways. It:

1. Enhances the construction and reconstruction of knowledge (if the learners are not ignorant).
2. Enables learners to identify their pre-conceptions of natural phenomena.
3. Assists learners to develop their own questions, plan scientific design, conduct activities and interpret result.
4. Helps learners to develop new knowledge by recrafting their existent conceptions.
5. Links science to relevant personal needs.
6. Provides a firm basis or reference for elaborating what has been learned.
7. Provides an effective revisionary model or learning method.

As explained in chapter 1, Vee diagramming includes a concept map on the left hand side titled, "My Understanding" which assists in the development of a plan for scientific discovery called "My Doing" with a Vee in the middle. According to Ausubel (1968), this method is an effective method to help learners to learn in a meaningful way. When

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new knowledge is assimilated into the cognitive structure of the learner, one can indicate that meaningful learning has taken place. This can only be achieved if the prior knowledge of the learner is introduced in the learning process. This can be accomplished by starting with the concept mapping strategy to externalize the preconceptions of the learners. The introduction of concept mapping will lay a solid foundation for the new knowledge to be attached. In the process the teacher also becomes aware of the students' ideas about the topic under discussion. Vee diagramming shows learners how a scientist's conceptual knowledge may be used as a lens to observe scientific inquiry and also displays the hierarchy of knowledge construction. It creates a medium of instruction that implies more than direct contact, and observation of objects and events. It is also different from demonstration and observational experience in the sense that it involves discovery, experience, and it is concerned with such aspects of the process of science, e.g. hypothesis formation and testing, designing and conducting experiments, controlling variables and making inference from the data. This method gives learners some appreciation for the spirit and method of scientific inquiry and for promoting problem solving, analytical and generalizing abilities (Ausubel, Hunesian and Novak, 1978). The actual practical part should not be confused with demonstrations because it involves a contrived type of discovery that is a very difficult autonomous activity. It is useful for the understanding of science because it gives scholars the flavour of scientific enquiry. The doing part carries the burden and conveys the method and spirit of science, whereas the textbook and the teacher share the burden of transmitting the subject-matter.

According to Ebenezer and Connor (1998), it's a research tool and evaluation technique adopted by thousands of teachers at all grade levels in diagnosis and testing instructional design on different topics in science. Esiobu and Soyibo (1994) contends that as its use has grown, attention has increasingly focussed on its reliability and validity especially by researchers who have began employing it along with other techniques in studying cognitive structure and conceptual change.

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Many studies in Africa and elsewhere has shown that learners experience great conceptual difficulty in understanding the concept of force (e.g. Adams, 2003; Ogunniyi and Fadkudze, 2002; Dekker and Thijs, 1998). Having established these facts, it seems logical to examine the effect of Vee diagramming in ameliorating incorrect conceptions. Evidence to date suggests that experimental groups receiving instruction in concept mapping and Vee diagramming demonstrate superiority over control groups (Lehman, Carter and Kahle, 1985; Okebukola, 1990; Okebukola and Jegede, 1988). Esiobu and Soyibo (1994) advocate that the correlation between Vee diagramming scores and conventional measures of learning such as formal course grades and scholastic aptitude tests are relatively low. This can be interpreted as evidence that common assessment techniques do not differentiate well between knowledge acquired through rote and meaningful learning. A study undertaken by Okebukola and Jegede (1988) found that concept mapping significantly improved 10th grade learners' achievement in science. Ebenezer and Connor (1998: 66) cited Wraith Malik a grade 5 science teacher's view on Vee diagramming and asserted the following:

> …I think that the biggest and best thing I learned from this experience is that I should never underestimate the potential and ability of the students. This strategy worked very well at the grade 5 level.

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Recent studies in Africa revealed no statistical differences between the performance of learners exposed to Vee diagramming and those exposed to traditional teaching techniques such as the "chalk and talk" (Esiobu and Soyibo, 1994). The main objective of this study is to measure the effect of Vee diagramming on grade seven learners' understanding of force. By incorporating Vee diagramming as an experimental instructional method, it is hoped to facilitate meaningful learning. Attention is being paid not to how material is to be taught but also how it will be learned.

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Conclusion

Constructivists believe that all learners enter the classroom with their own belief system distinct from that of school science (Ogunniyi, 1995; 2001). Most science curricula today are based on concepts, laws and theories which do not take the learners' worldviews into consideration. Hence, learners might sometime show no appreciation for the materials presented to them because it is contrary to their beliefs and cultural settings. Therefore, efforts should be made to meet the needs of learners and to include their prior knowledge into the teaching and learning process. Ogunniyi (1988) argues that learners should be made aware of the merits and demerits of science and the traditional worldview. This should be used to foster cognitive conflict and later conceptual integration which foster their overall understanding of the subject matter. This is precisely the focus of this study, namely to expose grade seven learners to the content of force again through the instrumentation of Vee diagramming. By choosing competent science teachers and also exposing the learners to this unique instructional strategy, it is hoped that they will not only be able to understand the concept of force better but will be able to make knowledge and value claims based on their practical experiences with the subject matter.

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CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter looks in detail at the experimental design, sampling procedure, and the development of the various instruments that were used to measure the learners' understanding of the concept of force. It also includes the motivation for using the instruments and explains how the data set was gathered for the research. The study sought to determine what conceptions grade seven learners hold with regard to the Newtonian concept of force. The study was conducted in a working class area dominated by high illiteracy rate, poorly trained teachers and poorly constructed and under-resourced schools. Also, no permission was required from the Education Department as both principals were willing to have the research conducted at the respective schools.

The instructional material used in this study is situated within the socio-cultural constructivist epistemology, which construes learners as active constructors of knowledge. Constructivists believe that learners do possess intuitive ideas or what Driver and Erickson (1983) refer to as "inventive ideas" based on their interpretation of sensory impressions which influence the way in which they respond to materials presented to them in the classroom setting. Kuiper (1998: 21) contends that the constructivist:

> Acknowledges that learners come into the classroom with their own context-based understanding of many concepts and skills that are to be dealt with through teaching. This naturally leads to the conclusion that learning needs to be contextualised within the learners' familiar environment in order to effectively deal with learner' ideas.

The strength of this theoretical model is its affirmation that intelligence is the product of constructed experience. Vee diagramming is an instructional tool derived from the constructivist paradigm, which has been found to facilitate understanding (e.g. Novak

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and Gowin, 1984). It is an instructional aid that helps to link ideas with concrete experiences. Details of Vee diagramming are provided in the next section.

The study adopted a quasi-experimental design modified after Solomon-3 Control Group design. Details of the design of the study are provided later. It was necessary to set up a general ability force test (GAFT) (see Appendix A) to asses the learners' scientific understanding. Other instruments used for gathering data included a concept of force test (COFT), a learners' questionnaire and interviews. It was hoped that the data from the COFT would reveal the learners' scientific and pseudo-scientific understanding, also referred to as "alternative" conceptions on force. However, before the instruments were administered to the learners, eight experts evaluated them by ranking the questions, from 1 to 5. A rating of 1 stood for a poor item while 5 stood for an item of high quality. The correlation of their rating was determined using the Spearman's Rank Difference formula. Details of this will be presented later.

Both quantitive and qualitative designs were adopted for this research. According to Presser, Mandelhall and Otto (1986) a quantitative design is more structured than a qualitative research design. Practically it involves a larger random or stratified sample. It tends to focus on answers to objective questions as in surveys or observations of actual behaviours. If carefully designed and executed its primary advantages are: 1) that it is generalizable; 2) the results can be used to make predictions with a high degree of probability; 3) it can be used to establish facts for statistically described phenomena; 4) extraneous variables can be controlled and 5) the control group can be used as a check for the treatment effect.

Qualitative research designs, on the other hand, are less structured and open ended by their very nature. It focuses more on one on one in-depth interviews. In a face-to-face meeting, the investigator can encourage learners to look deeper into a problem. He/she can clearly observe the facial and bodily expressions of the learners. Conclusions can also be drawn based on a learner's tone of voice. Information can also be obtained that will never be conveyed to him in a questionnaire. This implies that data can be gathered both verbally and behaviourally. However the data is balanced and the success or otherwise of this approach is very much dependent on the

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skill and sophistication of the researcher. Also the sampling does not permit scientific predictions.

3.2 Instructional Method

The instructional method used in this study was to measure the effect of Vee diagram on the learners' understanding of force. The aim of this instructional method was to:

a) Avoid learning that encourages memorization.
b) Deepen learners' understandings of the basic concepts of force.
c) Relate their understanding of force to real life issues.
d) Enable them to draw a Vee diagram.

Vee diagramming is a heuristic device that is used to illustrate critical ideas regarding the nature of knowledge and the process by which new knowledge is developed in scientific investigations (Ebenezer and Connor, 1998). This instructional method gives the learner a mental picture of a scientist at work. It is an instructional method that fosters creativity in the learning environment and avoids rote learning.

A Vee diagram normally includes a concept map that helps the teacher to know how to present the materials in an effective way such that learners' misconceptions from the curricular point of view are greatly minimized. Concept maps are constructed to present an individual's own understanding or ideas about a topic. According to Novak (1990), it probes knowledge structures of learners and assesses changes in the learners' understanding of science. The first phase of a Vee diagram consists of a concept map developed by the learners while the second phase involves the activities carried out by learners to solve a given problem. While the former provides the theoretical platform for an investigation, the latter involves the actual investigative activities, such as practical demonstrations and experiments with apparatus, which ultimately result in the ownership of the knowledge, skills or values gained in the process of conducting the investigation. It is for this reason that Novak and Gowin regard the first phase as "My understanding" and the second phase as "My doing" (Ebenezer and Connor, 1998).

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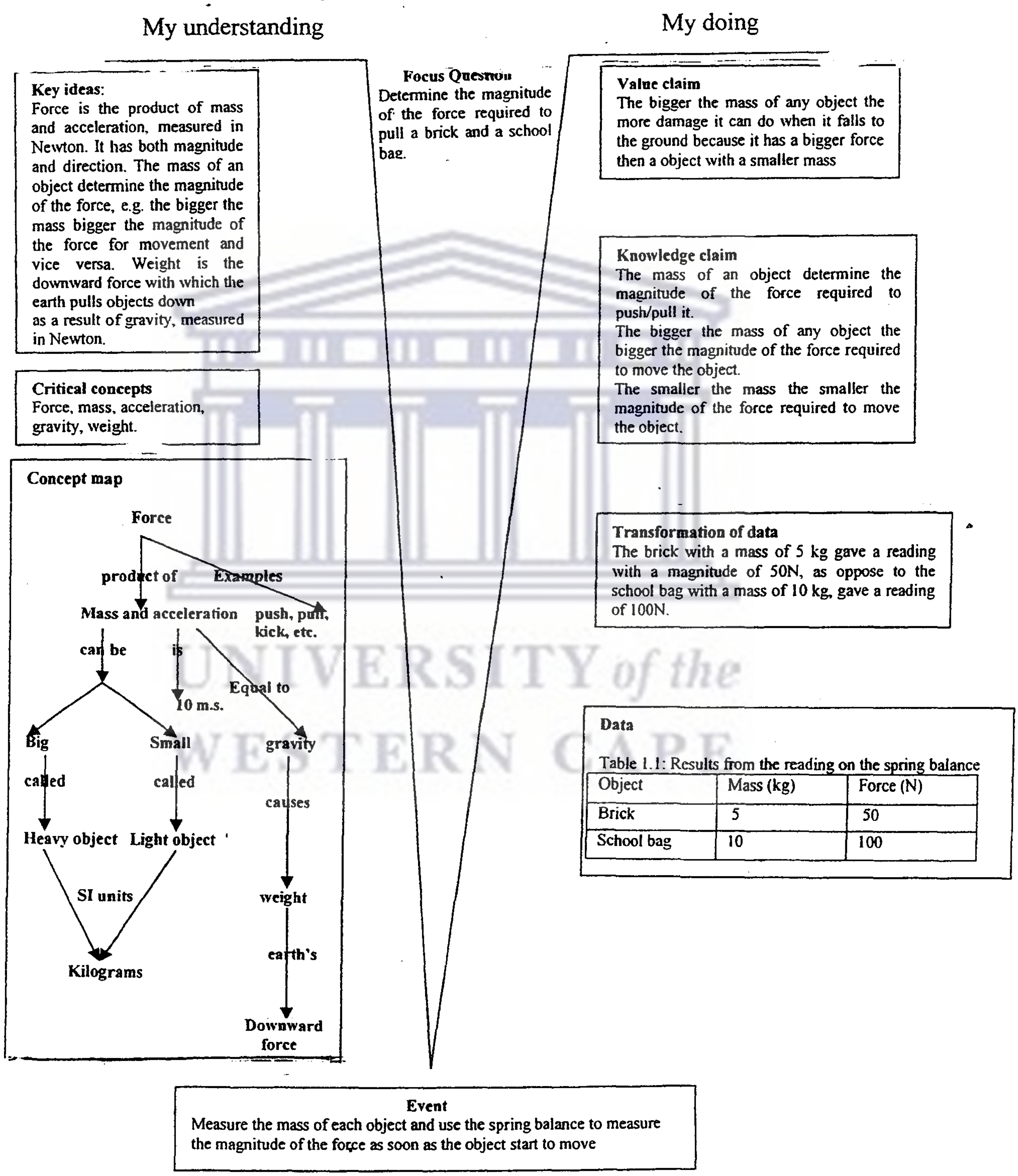
The study involved the development and use of a Vee diagram as an instructional tool for teaching the concept on force to grade seven learners, as can be seen in figure 3.1, presenting a model Vee diagram on force.

Figure 3.1: A model Vee diagram on force



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Specifically, the instructional package (see Appendix E) consists of instructions on how to construct a concept map and a Vee diagram on the concept of force. By reading the package the learners individually and collectively carried out various activities on force viz: (1) sketching out their concept maps and then working in groups to select or design concept maps on force; (2) developing their focus question on the concept; (3) conducting investigations; (4) recording and transforming data if necessary; (5) arriving at a conclusion or making knowledge claims and (6) indicating the application or use of the finding or making value claims (see Novak and Gowin, 1984). These activities were carried out in 2003 in eight double periods of normal class lessons to avoid disrupting the school timetable.

3.3 Sample and Sampling

A sample is a subset of measurements selected from a population. A researcher uses a sample to make inferences about a population on the basis of characteristics of the sample or, equivalently, the information contained in a sample (Schaeffer, Mendelhall and Otto, 1986). Three grade seven classes from two comparable schools were selected for the study. The comparability was established in terms of the following criteria:

1) The two schools were located in a similar socio-economic environment.
2) The schools' infrastructure and the qualifications of the teachers were also similar.
3) The result of the general ability test is also similar in the respective groups. The result of the t-value was 0.19 (see Table 3.1)

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The table below indicates the results of the learners' performance on the General Ability on Force Test.

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Table 3.1: The learners' performance on the General Ability on Force Test.

Group	N	Mean	Standard Deviation	t-test
School A	10	7.63	5.20	0.19
School B	10	7.20	4.33	

$p < 0.05$

The purpose of an experimental design is to establish a cause and effect relationship between one phenomenon and another. A researcher normally aims at establishing a causal relationship between a dependent and an independent variable (Johnson, 1992). The dependent variable in this study is the Vee diagramming and the independent variable is the learners' understanding of force. By manipulating the independent variable the researcher observes its effect on the dependent variable. As indicated earlier, the study was based on a quasi-experimental design modified after Solomon-3-contol group design. As can be seen in Table 3.2, this design consists essentially of three comparable (though intact) groups: an Experimental Group (E), the true Control Group (C) and another group controlling for the pre-test effect (C_2). The E group was exposed to lessons on Vee diagramming on the concept of force. C_1 on the other hand was exposed to the concept of force through the traditional chalk and talk method (Appendix F) while C_2, denied of the pre-test, was also exposed to the treatment condition as the E group. All three groups were taught by the investigator.

Table 3.2: A quasi-experimental design modified after Solomon-3-group

Class	Pre-test	Treatment	Post-test	Teacher
E	O_1	X	O_2	A
C_1	O_3	Expository chalk and talk	O_4	A
C_2		X	O_5	A

O_1 and O_2, and O_3 and O_4 stand for the pre-and post-tests for the experimental (E) and true control group C_1 respectively while O_5 is the post-test only for the second control group (C_2). X stands for the treatment.

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According to Ogunniyi (1992), the design is balanced and has the following merits:

a) It depicts the specific treatment and control conditions.
b) It includes both the pre-test and post-test.
c) The design controls for the pre-test effect.
d) It controls for most factors that could jeopardise the internal and external validity of the instruments

Ogunniyi (1992) states further that validity is concerned with whether or not an instrument measures what is supposed to measure. Reliability deals with the consistency or accuracy of an instrument. Hence, if an instrument is administered to the same group at two separate times, the results obtained should be similar. The researcher used triangulation and peer consultation to develop valid and reliable instrument. The instruments included GAFT, COFT, student questionnaire and interviews. All the instruments were critiqued and modified by eight experts including co-teachers, curriculum planners, a physicist and a science education professor.

3.4 Instruments

The study included the collection of both quantitative and qualitative data. The following instruments were used for the collection of data.

a) General ability test on force (Appendix A)
b) Concept of force test (COFT) (Appendix B)
c) Interviews (Schedule: Appendix C)
d) Student questionnaire (Appendix D)

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3.4.1 General Ability Test on Force

A general ability test on force was administered to three classes from two selected primary schools. The GAFT consisted of 11 questions, developed to test the general knowledge of the learners on force (see Appendix A). The items were scrutinized and evaluated by eight experts including four science education co-teachers, a physicist, two curriculum planners and a science education professor. The correlation coefficient based on the ranking of the experts was 0.78 using Spearman's Ranking Difference formula. This indicated that the prepared instrument attained an acceptable

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standard according to the experts. It was later observed that the scores on the GAFT were consistent with the scores the learners obtained in their Concept of Force Test (COFT).

3.4.2 Concept of Force Test (COFT)

The initial draft of the COFT consisted of 35 items. These were scrutinized by eight experts (i.e. four science teachers, two curriculum planners, a physicist and a professor of science education) to determine its suitability for grade seven learners to attain content, construct and face validity. Based on their critical comments the COFT was reduced to 26 items. The experts were asked to rate the items in terms of relevance and clarity. A clear and relevant question was ranked 5 and 1 if least relevant and least clear. The correlation coefficient obtained from their ranking stood at 0.78 using Spearman's Rank Difference formula. This index was considered adequate for validity purposes. The reliability index of the COFT was determined using Kuder-Richardson formula (KR_{21}) and stood at 0.80, which implied that the instrument attained a level of reliability.

The type of questions included the background and knowledge learners held with regard to force. Some of the questions were derived from an earlier instrument (e.g. Science Through Application Project - STAP), while others were derived from various sources. According to Johnson (1992), questions used from previous instruments tend to evince more valid responses than those that have not been tested. Learners were given ample time to complete the COFT. The researcher personally collected a total of fifty responses at the pre-test and seventy-five at the post-test.

3.4.3 Student Interview (SI):

An interview is an appropriate and effective method of gathering information and has a direct bearing on research. Takman (cited by Cohen and Manion, 1989) contends that interviews help researchers gather information by providing access to what is inside a person's head. They argue further that interviews make it possible to measure

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what a person knows, what a person likes or dislikes and thinks (attitude and belief). According to Schuman and Presser (1981) the procedure requires the interviewer to pose prepared questions to an interviewee and to then record the respondent's answers. The primary advantage of interviews is that people will usually respond when confronted in person, which allows the researcher to note specific reactions and eliminate misunderstandings about the questions asked. Any movements, facial expressions or statements made by the interviewer can affect the responses obtained. They are free to expand on a topic as they see fit, but limited to give directives with probing questions.

Two types of interviews exist in research, namely, structured and unstructured interviews. According to Schuman and Presser (1981) a structured interview consists of pre-specified questions and the response of the respondent is greatly restricted. An unstructured interview in turn allows the respondent to freely express his/her view on a certain issue. It is in this light that the researcher used unstructured interviews.

A structured interview consisting of sixteen questions was produced and administered to the learners after they had been exposed to the instructional model (see Appendix D). The panel that validated the COFT was used to validate the interview schedule. The correlation coefficient of their ratings stood at 0.72 using the Spearman's Rank Difference formula. This implied that the prepared interview attained an acceptable level of validity. The interview questions were based on the learners' responses to the COFT. The focus was on their attitudes, motivation and the conceptual difficulties the learners experienced during the instructional activities. However, only six of the willing learners from the experimental and control group two were selected for the interview. All the interviews took place in the staff room and with the permission of the learners, a tape recorder was placed between the interviewer and the learner. Although it was the first time the learners were exposed to a procedure it did not seem to affect their responses in a negative manner.

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3.4.4 Student Questionnaire (SQ)

For additional contextual information a student questionnaire was included to give a more holistic analysis of the data. A questionnaire is a useful way of collecting a large amount of data. If a survey is to obtain information from people, then many non-sampling errors should be controlled by the careful design of the items (Scheaffer, Mendelhall and Otto, 1986). According to Schuman and Presser (1981) the literacy level of the learners should be considered with the construction of the items. The body language or the phrases used should be understandable and at the level of the learners. Open-ended questions or closed questions can be used for data collection. Schuman and Presser (1981) contend further that open questions allow the respondent to express some depth and shades of meaning in the answer as opposed to close questions that may not always provide the appropriate alternatives, and the alternatives listed may themselves influence the opinion of the person responding. Closed questions, on the other hand, are useful for obtaining quantitative data and they allow for easy data coding and analysis. Based on this premise, both open ended and closed questions were adopted for the study.

The SQ consisted of 24 items. The correlation coefficient based on the ratings of the expert panel using Spearman's Ranking Difference formula was 0.84. This was considered adequate for the purpose of validity. Further details of the SQ can be found in Appendix D. The overall return rate of the SQ was 100% as the researcher personally administered and collected the questionnaires.

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3.5 Conclusion

This study sought to determine what pre- and post- treatment conceptions grade seven learners hold with regard to the concept of force. This chapter provides details on the quasi-experimental design, details and rigours involved in the development of the instruments. It provides the validity and reliability indices of the instruments and the procedure used to obtain both qualitative and quantitative data. The next chapter will present data analysis and discuss the findings based on the data obtained.

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CHAPTER FOUR

RESULTS, ANALYSIS AND DISCUSSION

4.1 Introduction

This study sought to determine three samples of grade seven learners' conceptions of force. A related aim was to determine the effectiveness of Vee diagramming in ameliorating the incorrect conceptions about force. The study involved three comparable groups of grade seven learners. The experimental group (E) and the second control group (C_2) were exposed to Vee diagramming while the true control group (C_1) was taught through an expository lecture approach, full details are recovered in Appendix E. All the groups were taught by the investigator. Further, six learners in the experimental group was interviewed to gain a deeper insight about whether or not Vee diagramming enhanced their understanding of the concept of force. An analysis of the findings is presented in the sections that follow.

4.2 Pre-test results

The Concept of Force Test (COFT) was administered to 25 grade seven learners constituting the experimental group (E) and 25 other learners in the true control group (C_1) at the pre-test stage. The performance of both the experimental and the true control groups was relatively poor with scores ranging between 0 and 18 out of a total of 35 marks. A high mean score indicates a good conceptual understanding of force and a low mean the opposite. The mean of the experimental group was 7.20 and that of the control group was 7.76. The t-value was -1.62 (At $p = 0.05$ and $df = 48$). A critical t-value of 1.68 is needed to reject the null hypothesis, suggesting no significant difference between the two groups at the pre-test stage as far as the concept of force is concerned (Table 4.1).

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Table 4.1: Pre-test Results on the Concept of Force Test (COFT)

Group	N	Mean	Standard Deviation	t-test
E-group	25	7.20	1.98	t-calc. –1.62 (p=.05; df=48)
C1-group	25	7.76	2.05	

p = 0.05

4.3 Assessment framework

An assessment scheme modified after two assessment frameworks developed by Abrahams, Grzyboowsky, Renner and Marek (1992) and Athee and Varjola (1998) were used to analyze the various conceptions and alternative conceptions that the learners held with regard to force. The original framework had six categories: "no response"; "no understanding"; "specific misconception"; "partial understanding with specific misconception"; "partial understanding"; and "sound understanding". In this study, the specific misconception and partial understanding with specific misconception were collapsed into the 'misconception" category. Table 4.2 below provides the specific criteria used to describe the various categories of understanding of force demonstrated by the learners involved in the study.

For ease of reference, the assessment framework - consisting of five different levels of understanding alluded to above - are designated with letters A-E (Table 4.2). A glance at Table 4.2 reveals which items or themes have or have not been mastered. In other words, the learners' understanding about force increases from A-E. The higher the percentages congregating around D and E indicate some measure of understanding of the concept. Alternatively, higher percentages congregating on A to C depict a lack of understanding or poor understanding of the concept.

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Table 4.2: Assessment Framework Depicting Levels of the Learners' Understanding of Force

Degree of understanding	Characteristics
A. No response	- Leaving answer sheet blank - I do not know - I do not understand
B. No understanding	- Repeating the question - Inappropriate or irrelevant responses
C. Misconception	- Illogical, incorrect responses - Erroneous or pseudo-scientific conceptions - Alternative conceptions
D. Partial understanding	Response includes at least one or some aspects/components of the valid scientific understanding but not all the components
E. Sound understanding	- Response includes all the components of the validated response

The COFT consisted of 26 questions (see appendix B) which were summarized and grouped together for ease of reference (see Table 4.3). Item 1.1, 1.2 and 2k deal with the concept of force. Learners were expected to use their pre-existing knowledge to describe the concept of force. The aim was to test their background knowledge in order to reveal the various conceptions or misconceptions they held about the concept.

To put the concept of force in context, certain items dealing with related concepts have been included on the COFT. For instance, items 1.3, 2 and 4.5 are concerned with mass and weight and tested the learners' level of understanding in terms of the following:

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- The learners' understanding of mass and weight.
- The differences between the two concepts.
- How the concepts differ or relate to each other and to force.

Item 3 tests the learners' background knowledge about gravity. They are expected to explain:

i) The effect of gravity on objects.

ii) Why objects fall to the ground.

iii) The different gravitational forces and the different types of forces.

Items 4.1 to 4.4 constitute another way of testing the learners' conceptions of gravity and their application to real life situations.

Table 4.3: Grade 7 Learners' Understanding of Force in Percentage at the Pre-test Stage

Force and Associated Concepts	Levels of learners' understanding of concepts									
Summary of Question Items	Expt Group (%)					Control Group (%)				
	A	B	C	D	E	A	B	C	D	E
Force:										
1.1 Which of the following statements best describe the term force? ...	-	12	20	36	32	-	-	40	32	28
1.2 On the moon people? ... (walk/gallop/swift/run)	20	16	-	4	60	8	8	48	-	36
2k Explain in your own words what you think force is.	20	8	28	40	4	20	28	32	20	-
Sub-total	13	12	16	27	32	10	12	40	17	21
Mass and Weight										
1.3 The bigger the ...... the bigger the force.	4	-	56	36	4	20	52	12	16	-
2a Can you pick up a truck with one hand? Yes ( ) No ( )	4	-	56	36	4	20	52	12	16	-
2b In your opinion is Siphiwe's father really strong?	4	-	56	36	4	20	52	12	16	-
2c Does the truck in the above text have a small or a big mass? Explain your answer.	12	12	56	12	8	12	40	24	24	-
2d Explain in your own words your understanding of mass.	12	12	56	12	8	12	40	24	24	-
2e,f. Is their any difference between mass and weight? Yes ( ) No ( ). Explain your	28	-	68	4	-	26	26	32	12	4

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Force and Associated Concepts	Levels of learners' understanding of concepts									
Summary of Question Items	Expt Group (%)					Control Group (%)				
	A	B	C	D	E	A	B	C	D	E
answer.										
4.5 Weight and mass is the same thing. Agree ( ) Disagree ( ).	28	-	68	4	-	26	26	32	12	4
2g. Is their any relationship between the mass of an object and its force?	64	4	32	-	-	36	40	20	4	-
2h, i, j. What are the SI units for mass, weight and force?	84	8	-	8	-	36	44	8	12	-
Sub-total	27	4	50	16	3	23	41	20	15	1
Gravity and Gravitational forces:										
3a. Will the boy's arm become tired if he should hold the book for longer than 10 minutes in his outstretched arm? Yes ( ) No ( ).	20	28	52	-	-	12	64	20	4	-
3b. Explain your answer.	20	28	52	-	-	12	64	20	4	-
3c. Are their any forces present in the diagram?	48	24	24	4	-	20	48	16	12	4
3d. Name the forces.	48	24	24	4	-	20	48	16	12	4
3e. Explain what will happen if the boy drop the book?	32	44	24	-	-	20	36	20	20	4
3f. Explain your answer.	32	44	24	-	-	4	36	20	20	20
Sub-total	33	32	34	1	-	15	49	19	12	5
Gravity and its effect on bodies:										
4.1 The earth exerts a force on your body. Agree ( ) Disagree ( ).	28	16	28	20	8	4	20	4	40	32
4.2. The force the earth exerts on your body is called gravitational force. Agree ( ) Disagree ( ).	20	24	16	36	4	12	20	24	24	20
4.3 There is no difference between the force on the earth and the force on the moon. Agree ( ) Disagree ( ).	16	18	22	30	14	20	16	24	24	16
4.4 A force is applied when you refuse to do something against your will. Agree ( ) Disagree ( ).	10	16	20	20	34	16	12	22	46	4
Sub-total	19	19	22	22	16	13	17	19	33	18

Note: Coding is based on degree of understanding

A-No response; B-No understanding; C-Misconception; D-Partial Understanding;

E-Sound understanding.

Expt group (n=25), Control group (n=25).

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4.4 Performance of learners on individual pre-test items.

4.4.1 Force

Item 1.1 and 1.2 are multiple choice questions which required the learners to choose the most correct answer from four different options. Item 1.1 expects the learners to recall their background knowledge about force. The results indicate that 32% of the learners in the experimental group and 28% in the control group demonstrated a sound understanding of force. The performance is quite poor when one considers that most of the learners ought to have been exposed to the topic in the previous grades. A total of 20% in the experimental group and 40% in the control group held misconceptions about force and 12% in the experimental group demonstrated no understanding (Table 4. 3)

Item 1.2 expected the learners to apply the knowledge they held about force to real life situations. In the experimental group 20% of the learners left the question unanswered, four percent held a partial understanding and 60% displayed a sound understanding. In the control group eight percent showed no understanding and 48% held all kinds of misconceptions while 36% demonstrated a sound understanding of the concept. The overall performance in item 1.1 and 1.2 (experimental and control groups) was generally poor. No written responses of the learners on these items were required. Rather, only their comprehension ability was tested.

Item 2k expects the learners to express their own understanding of force. The results were as follows: 20% in both the experimental and control groups left the question unanswered, eight percent and 28% in the experimental and control groups respectively showed no understanding. Again, 28% in the experimental group and 32% in the control group showed all kinds of misconceptions and only four percent in the experimental group displayed a sound understanding of force. The language usage of these learners in attempting to answer the question was very poor. Their ideas often were incoherent, inappropriate and riddled with words with multiple meanings. Here are some examples of the responses of the learners on the item requiring them to articulate in their own words their understanding of force:

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"If you say go to the shop now."

"Force is strength."

"Father say thank you."

"If you force me to do something."

Not only are the statements above incoherent and grammatically incorrect, they also reveal the learners' use of commonsensical meanings or cultural metaphors (see Rollnick and Rutherford, 1996) instead of the scientific understanding required to answer the question. Similar patterns and results have been observed in studies in South Africa and elsewhere (Adams, 2003; Dekker and Thijs, 1998; Ogunniyi and Fakudze, 2002). The learners experience great difficulties in organizing their ideas coherently or sensibly. Most of them referred to force as strength, power or masculinity. Ogunniyi (2001) advocates that force is one of those concepts that evince all kinds of misconceptions. He argues further that the learners will only absorb concepts in science that are not in conflict with the cultural usage of such concepts. To him, the learners' views have been developed and reinforced over time simply by growing up in a culture. In other words, learners' worldviews are the products of their historical and socio-cultural influences as well as their individual constructions (Ogunniyi, 1987). Teachers are consistently confronted with ideas that learners bring to class which are not in harmony with school science. Children build their ideas and explanations on their personal experiences with the natural world. Aikenhead (1996) contends that if a learner's traditional worldview is ignored in the learning environment, science will become to him a fact-orientated and a memorization-oriented course.

4.4.2 Mass and weight

Item 1.3, 2a to j and 4.5 deal with the issue of mass and weight.

In these items learners were expected to:

- Show a sound understanding of mass and weight.
- Distinguish between the two concepts.
- Show the relationship between mass, weight and force.

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The results in Table 4.3 show that the overall performance of the learners in these items was generally very poor. Item 1.3, 2a and 2b tested the learners' own conceptions of mass. Only four percent in the experimental group could display a sound understanding of mass while 52% in the control group had no understanding about the concept. A total of 56% in the experimental group and 12% in the control group held all kinds of misconceptions. Most of the learners confused the term mass with size and weight. This is not surprising when one considers the weak explanations given about these concepts in different textbooks. For example, some textbooks explain the term mass in terms of measurements taken on a scale and weight as the force with which the earth pulls down an object. The differences between the terms are neither highlighted nor explicitly defined. The intuitive ideas of the learners are usually ignored in the textbooks. A hindrance to the learners' conceptualization of mass and weight perhaps, could be that while the latter is commonly used in the everyday experience, the former is encountered mainly in the science classroom. The following statements are representative of the learners' conceptions of mass:

"Is weight"

"A mass is a weight of a person'

"Thing is heavy or not"

Item 2c and d expected learners to relate the different sizes of objects to mass. Only eight percent in the experimental group (and none in the control group) showed a sound understanding of the question. About 56% in the experimental group and 24% in the control group held misconceptions about the concept. They refer to the size of the objects as either heavy or light. Another 12% in the experimental group and 40% in the control group displayed no understanding (i.e. category B responses). Their explanations were generally vague and inappropriate to the question. Here are some of the responses of the learners on this item:

"It is a mass soogar"

"May be Siphiwe tell lies"

"I will believe it when I see it"

"No one can pick up a truck with one hand"

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Item 2e, f and 4.5 expected the learners to distinguish between mass and weight. No one in the experimental group and four percent in the control group gave a scientifically valid response. About 28% in the experimental group and 26% in the control group left the space unanswered and 68% in the experimental group and 32% in the control group respectively gave all kinds of misconceptions about the concepts. Here are some of the responses of the learners when they were asked to differentiate between mass and weight:

> "Weight is when you are on a scale"
>
> "There is no difference between mass and weight because mass is something heavy and weight"
>
> "No it's the same thing"
>
> "Mass is a large amount and weight"

Item 2g expected the learners to explain the relationship between the mass of an object and force. No one in the experimental group or the control group held a sound understanding about the item. Only four percent in the control group as opposed to none in the experimental group showed partial understanding, while 64% and 36% in the experimental and control group respectively left the question unanswered.

Items 2h, i and j were also poorly answered by the learners in both the experimental and control groups. These items required the learners to give the SI units for mass, weight and force respectively. Nobody in the experimental or control group could give the correct answer. Those that attempted to answer the question gave inappropriate or illogical responses (i.e. category C level of understanding). In the experimental group, eight percent had no understanding as opposed to 44% in the control group. Similarly 84%, and 36% of the experimental and control group respectively left the item blank.

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4.4.3 Gravity and gravitational forces

Item 3 consisted of six questions. The entire item deals with gravity and gravitational forces. Learners were shown a drawing of a boy holding a book with an outstretched arm for 10 min. They were expected to:

a) Explain the effect of the book on the boy's arm.

b) Identify the different forces present in the diagram

c) Explain or give reasons why objects fall to the ground.

The results indicate that the learners held a poor conceptual understanding of gravity. In item 3a and 3b the following results were evident: 52% and 20% of the learners in the experimental and control group respectively held all kinds of misconceptions about gravity. Another 28% in the experimental group and 64% in the control group had no understanding at all about the concept of gravity. The learners used the term very loosely without providing any scientific or logical reasoning in their explanations. Most of them argued that objects only fall to the ground because it can not stay in the air. Here are some of the responses of the learners:

> "The book cannot stay in air"
>
> "The boys arm get tired and book fall to the ground"
>
> "The book will brake when it fall to ground"

In item 3e and f, 32% of the learners in the experimental group and four percent in the control group could not explain what happens when a book is dropped unto the floor. Another 24% in the experimental group and 20% in the control group held misconceptions about a falling book. Compared to the control group with about one fifth demonstrating some understanding no one in the experimental group could showed a partial or a sound understanding about items 3e and f. Only four percent in the control group could explain what happens when a book fall to the ground. The poor response to item 3e and f could be that the teacher either did not understand the concept, or did not explain clearly the dynamics involved when gravitational forces act or work, or when objects fall to the ground.

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4.4.4 Forces related to gravity

Items 4.1 to 4.4 were fairly well answered. No written responses were required and one-word answers were expected. Learners were given a statement about the relationship between force and gravity, they either had to agree or disagree with the statements. Everyone in the pre-test group attempted the questions. On item 4.2 the learners either had to agree/disagree with the statement that the earth, exerts force on their bodies. About four percent in the experimental group and 20% in the control group had a sound understanding, 24 % in the experimental group and 20% in the control group had no knowledge of the item while 16% in the experimental group and 24% in the control group held misconceptions based on their responses to the questions while 28% and four percent of the experimental and control group respectively left the item blank. Item 4.3 tests the learners' understanding of gravitational forces that exist on the moon. Sixteen percent in the control group and 14% in the experimental group had a sound understanding, 18% in the experimental group and 16% in the control group had no understanding and 22% in the experimental group and 24% in the control group respectively held misconceptions.

4.5 Learners' language difficulties

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According to Kilfoil (1999) one of the causes of poor performance in science is due to learners poor language facility. He contends that linguistically weak learners will perform poorly in science due to their low language skill. The responses of the learners to the items indicate language inadequacies. These learners show vocabulary difficulties which might have resulted in comprehension difficulties in that they were unable to read and understand the questions as expected. They lacked the use of conjunctives such as because, hence, therefore, etc. Some of the learners during discussions claimed that their poor English skill affected their understanding of some concepts. Here are some examples of language deficiencies in the written responses of the learners on the COFT:

"It you arm will get sore"

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"It will smoch you"

"Pages will brake when book fall to ground"

"His arm get tired from heavy book"

The responses above demonstrate both linguistic and conceptual difficulties. According to Ogunniyi and Taale (2004: 84):

> Linguistic problems relate to the inability of learners to express themselves in a clear and comprehensible manner. This problem is vividly demonstrated in various ways. For example, some learners copy down verbatim the questions. Others copy down the Xhosa and Afrikaans words in parentheses used to explain the difficult English words, while still others seem unaware of correct grammar.

Most of the learners did not attempt to answer questions that demanded the use of their own ideas in their own words. They simply left the questions unanswered. For example, item 3e expected the learners to explain the concept of gravity in terms of a book falling to the ground, 32% in the experimental group and 20% in the control group left the space blank with no answer. An Afrikaaans speaking learner confirmed in the interview that he would try to answer a question only if it did not demand a long answer. Some of the learners that attempted to speak English in class were laughed at. An analysis of how these learners answered the rest of the items clearly shows that they lacked plain, basic and correct English. The sentence construction of the learners was poor and often inappropriate. Here are some of the responses of the learners when they were asked to explain in their own words what they think mass are:

"Mass is a same thing"

"When scale says mass toorrraar"

Most of the learners indicated that their greatest problem were the concepts used to describe force. They claimed that the concepts used were generally abstract and not used in their daily lives. They were surprised at the scientific definition of the concepts as opposed to their own understanding. Others complained about how difficult it was to understand the terms. Some of the learners preferred to memorize the terms instead of

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having a good understanding of the concepts. Ogunniyi (1996) argues that the learning of science makes its own language demands, firstly because of the complex and abstract nature of the concepts involved and secondly, because of the special terminology involved.

As indicated in chapter 2, Kulkarni (1988) advocates that learners from high poverty background areas enter school with restricted speech abilities and are likely to develop language difficulties. He argues further that learners from such background areas lack meaningful linguistic interaction with educated individuals that may influence their language usage positively. According to him: "children of educated parents can express even at their school going age concepts like, a cow is useful because she gives milk" (Kulkarni, 1988).

The home language of 50% of the learners is Afrikaans. As an Afrikaans speaking person, I empathize with these learners because I went through the same experiences of seeking first of all to translate scientific concepts present in English into Afrikaans to gain conceptual understanding of such concepts. Although science instruction in South Africa is presented in Afrikaans throughout their school career, they are still likely to encounter problems with certain abstract scientific concepts, more so in the English language. Scientific concepts are best learned and understood in the learners' mother tongue regardless of the technical limitation of the language. The greatest problem facing the learners is that they do not use English in their daily lives to improve their language skill. English nomenclature of scientific concepts has no direct relation or equivalence to the Afrikaans language. In this regard the dictionary does not help them to overcome such problems. Therefore, learners cannot appeal to translation into their mother tongue for resolution of doubt or the dissipation of ignorance (Strevens, 1976). This result in science becoming a memorization-based subject. If teachers talk slower using fewer and simpler words to explain certain phenomena, this may help the learners to comprehend certain concepts. The use of diagrams and concept maps in science does not require the use of long sentences and explanations to transmit information to the learner. By using such alternative strategies such as demonstrations and drawings, less emphasis will be

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placed on language and its complexities and learners will then be able to respond in a language with which they are most familiar.

According to Rosenthal (1995) the emphasis on language should be to present science to learners in a "caretaker speech" or "foreigners talk" method. Sentences must be shortened, teachers must talk slower, and use simpler words and gesture. The intention of "foreigner talk" is to improve the communication skill and comprehension abilities of the learners. This way, they will understand and conceptualize information presented to them better. The teacher must make it their responsibility to develop a harmonious relationship between school science and the language of instruction. If teachers want science to become more appreciable and relevant to learners than the language of instruction should be at the level of such learners.

4.6 Six learners attitude towards science

An attitude is a very complex phenomenon. It cannot be measured directly but can be inferred from behavioural manifestations. Behaviour may be observed but one can only speculate on the mental condition that produced it (Ebel; 1969). The development of a positive attitude towards learning is a desirable educational outcome. According to Brewer (1969) attitudes held by learners influence their performance in a direct way. With the exception of one learner everyone that was interviewed gave similar positive responses when they were asked whether or not they liked science. Here are some of their responses.

> S_1: Yes. I like science. I just love it. I find it interesting no matter where you go, you must have it. I like physics and when I go to high school I will do it. The teacher makes it fun.

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S_2: Yes. For the sake of the teacher.

S_3: When our teacher learn us about science and we do not understand she does not talk further, and when we don't understand we will put our hands up and she will explain it again.

The following statement was made by a female (S_6) who did not have any personal interest in science.

S_6: No. In a way it is a bit difficult, but sometimes also very easy. I just do not have any interest in science.

The responses indicate that the teacher plays a notable role in the learners' perceptions of science. Therefore, their attitudes may help learners to assign value to, or take a particular stance towards science. The professional responsibility of teachers and the desired aim of a school greatly influence the classroom environment. The classroom environment in turn influences the attitude of learners. Teachers who lose interest in teaching as a result of changes in the curriculum or overall changes in the Department of Education (e.g. South Africa and the implementation of OBE) immediately affect the attitude of learners negatively. Learners adopt an "I don't care attitude" because the teacher's attitude has a direct bearing on them. Learners with a positive attitude towards science will develop a deeper understanding towards materials and achieve more in science. Therefore factors such as irrelevant curriculum and ineffective teaching need to be identified and addressed. Curriculum planners and textbook authors should not ignore the intuitive ideas of learners in the teaching and learning programme. If the preconceived ideas of learners are ignored in the science classroom, learning becomes a laborious endeavour. Teaching should be learner-centered, i.e. schools must facilitate the development of certain skills and attitudes of learners called for by the science community. School science must move away from a curriculum that aims at teaching science for the sake of science, but towards a science learning where both learner and society benefits (Kuiper, 1998).

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Vee diagramming facilitates a pedagogy that promotes active learning by the learners. For instance, the aspect known as "My understanding" within the Vee diagram have been found to positively influence learners' conceptual development because they could relate their own experiences with the scientific conception (Ebenezer and Connor, 1998). The learners involved in the study were given opportunities to share their ideas and construct their own concept maps of their own understanding of force. A learner asserted that they enjoyed sharing their ideas instead of being passive in the science class. When the learners were asked about the relevance of science to their daily activities, all the learners interviewed gave similar responses. The following statement made by one of the learners summarizes such responses:

> Science is fun. Especially the part where you perform experiments. You need science everywhere you go. At home I sometimes test the stuff we learn at school in the science classroom.

4.7 Summary of findings at the pre-test stage

At the pre-test stage 32% of the learners in the experimental group and 21% in the control group showed a sound understanding of the concept of force. Sixteen percent and 40% in the experimental and control group respectively displayed all kinds of misconceptions. Some learners confused the concept of force with strength and power. Others defined the concept in terms of their everyday usage of the word. Thirteen percent in the experimental group and ten percent in the control group left the answer sheet blank. These findings corroborate earlier findings in the area (Ogunniyi and Fakudze, 2002; Dekker and Dekker, 1998).

A total of four percent in the control group could distinguish between mass and weight, as apposed to none in the experimental group. About 68 % of the learners in the experimental group and 32 % in the control group suggested that mass and weight have the same meaning. To those learners mass is the same as weight. When they were asked

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whether there is a difference between the two terms, the following statements were given by some of the learners:

"My weight is measured on your scale and it is measured in kg."

"It is same thing".

"There is no difference between mass and weight because mass is something that is heavy and weight"

Majority of the learners in both the experimental and control group experienced great difficulty in expressing their understanding about gravity and its application to real life situations. The learners used the term gravity very loosely with no scientific relevance. To them, gravity is when things fall to the ground by mistake. Others argued that objects cannot stay in the air because it encounters a lot of wind which push it down. This finding confirms a similar finding reported (e.g. Emereole, 1998). In the entire pre-test group a total of 33% in the experimental group and 15% in the control group left the space unanswered while only five percent in the control group displayed a sound understanding about gravitational forces. Further 34% and 19% in the experimental and control groups respectively held all kinds of misconceptions about gravity and gravitational forces. With regards to gravity and its effect on bodies 19% and 13% in the experimental and control groups respectively left the questions unanswered while only 16% in the experimental group and 18% in the control group displayed a sound understanding. Further, 22% in the experimental group and 19% in the control group held misconceptions while 22% and 33% in the experimental and control group respectively displayed partial understanding. Similar patterns were observed in other studies as well (e.g. Adams, 2003; Gunstone and Watts, 1985; Emereole, 1998)).

The school where this study was conducted strictly follows the sallybus prescribed by the Department of Education. The information found in the prescribed sallybus does not take cognizance of the learning difficulties or linguistic inadequacies learners are face with. For instance, the learners do have experiences with force and gravity, and know what happens when one drops, pushes, pulls, kicks or moves objects. These experiences result in the learners' development of theories and explanations about aspects surrounding them

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(Driver, 1983). It is hoped that curriculum planners, textbook authors and teaching programmes will be cognizant of such findings. Issues relating to these stakeholders will be raised later.

The results presented so far indicate that the learners involved in this study, for one reason or another, are unable to articulate in a clear and concise manner valid conceptions of force and associated concepts such as mass, weight and gravity. In terms of the five levels of understanding ranging from 'No response' to 'Sound understanding' (Table 4.2 and 4.3), the learners can be regarded as holding generally an inadequate concept of force. Faced with the reality of the learners' inadequate understanding of the concept of force, the study sought for ways through which the learners' misconceptions could be remedied. As explained in chapter 3, the study adopted an instructional model based on Vee diagramming as espoused by Novak and Gowin. This instructional model first developed by Gowin in 1984 was inspired by the constructivist epistemology which construes knowledge as a derivative of deliberate construction of ideas (Ebenezer and Connor, 1998). To Novak and Gowin (1984), Vee diagramming is a heuristic tool used to visually organize science concepts and ideas. This approach helps to illustrate the key ideas regarding the nature of knowledge and the process by which new knowledge is made in scientific inquiries. It helps learners to know how knowledge is constructed and reconstructed as well as derive their own meanings based on direct experience with phenomena (Ebenezer and Connor, 1998).

As indicated in chapter 3, two groups of learners were exposed to two different instructional methods. Of these two, one (i.e. the experimental group, E) was exposed to eight double periods of Vee diagramming while the true control group (C_1) was taught through an expository lecture method. The third group (i.e. control group two, C_2) was also exposed to the same Vee diagramming instructional model. The E group and the C_1 were pre-and post-tested on the COFT while C_2 was exposed to the post-test of the COFT only but not pre-tested. The purpose of including C_1 was to control for the pre-test effect. The findings at the post-test stage are presented in the sections that follow.

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4.8 Post-test descriptive statistics

At the post-test the learners obtained scores ranging between 0 and 23 out of a total of 35 marks. The mean of the E group at the pre-test was 7.20 compared to 8.84 at the post-test, i.e. a mean gain of 1.64. The mean scores of the E and C_2 group (also exposed to treatment) were very close (8.84 and 9.20 respectively). Although the E and C_2 group had slightly higher mean scores than the C_1, the overall difference was not statistically significant. The mean of the true control group (C_1) remained essentially the same at both the pre-and post-test.

Table 4.4: Performance of the Learners on the COFT at the Post-Test Stage

Groups	**Post-Test**		
	N	**M**	**SD**
E	25	8.84	5.82
C_1	25	7.36	4.69
C_2	25	9.20	5.56

The pre-test results indicated that the overall knowledge of the learners was generally very poor. However, an analysis of the post-test scores shows no significant shift in their performance or understanding about force. The descriptive statistics above give rise to the following questions: i) Are the higher mean scores of the treatment groups statistically significant? ii) Is the observed difference attributable to the effect of the treatment?. In order to infer anything from the post-test data, both the F-test and the t-test pair-wise comparison were carried out. It is important to note at this point that the three groups E, C_1 and C_2 are comparable (see chapter 3). The ANOVA results of the post-test scores for all three groups are shown in Table 4.5 below.

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Table 4.5: Analysis of the variance of post-test sores on the COFT.

SOURCE	SS	DF	MS	F-RATIO
Between groups	37.30	2	18.65	0.61
Within groups	2194.63	72	30.40	
Total	2231.94	74		

The F-ratio for the post-test scores of 0.61 is less than the critical value of 3.15, i.e. $F(2, 72) = 3.15$ at $p < 0.05$ needed to falsify the null hypothesis. This suggests that the differences among the groups are not statistically significant at $p < 0.05$ level. The same conclusion was reached when pair-wise comparison was computed (see Table 4.6)

Table 4.6: T-test pair wise comparisons of post-test mean scores on the COFT

Pair Groups	t-test values (p = 0.05)
E and C_1	t-obs = 0.98 < t-crit =1.684 ,df (48)
E and C_2	t-obs = 0.22 < t-crit=1.684, df (48)
C_1 and C_2	t-obs = 1.27 < t-crit=1.684 , df (48)

Table 4.7 below shows the comparisons of the pre-post-test mean scores of the three groups on the COFT.

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Table 4.7: Pre-test and Post-test scores according to the treatment groups on the COFT

Variable label	**Pre test**		**Post test**		
	Mean	**SD**	**Mean**	**SD**	**t-test**
E	7.20	1.98	8.84	5.82	-1.62
C_2	-	-	9.20	5.56	
C_1	7.76	2.05	7.30	4.69	- 0.39

A t-ratio greater than 1.68 (at $p = 0.05$ and $df = 48$) is needed to reject the null hypothesis suggesting a significant difference. However, in no case was any t-value as large as 1.68, this implies that no statistically significant difference exists between the pre- and post-test scores. Though there was a mean difference between the pre-and posttest of the experimental group, the difference is not statistically significant. In the case of the true control group (C_1), the post-test mean score is actually lower than the pre-test mean score but again, the difference between the two is not statistically significant. The reason for the reversed performance of the control group (C_1) cannot be explicitly explained at this exploratory stage, it might be possible that the language of instruction affected the performance of the learners because they were an Afrikaans mother tongue group. Further investigation and close up interviews might provide better insight into the phenomena responsible for the reversed performance. Other than the quantitative descriptions the learners were asked to express their views about Vee diagramming as a method of instruction. Table 4.8 below indicates the learners' viewpoints.

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Table 4.8: Learners' Perceptions of Vee diagramming as a tool for learning

	Agree	Disagree	No opinion
a) Vee diagramming helps me to understand the topic on force better	86%	-	14%
b) Vee diagramming help me to organize my ideas about force better	84%	-	16%
c) Vee diagramming is confusing	8%	78%	14%
d) Vee diagramming does not allow me to easily forget what I learned about force	74%	12%	14%

The results in table 4.8 indicate that:

- About 86% of the learners agree that Vee diagramming helps them to understand the topic on force better.
- A total of 84% agree that Vee diagramming helps them to organize their ideas better
- About 78% of the learners' disagree that Vee diagramming caused confusion.
- 74% of the learners claimed that Vee diagramming helps them to remember the information for longer periods. From the responses in Table. 4.8, it can be said that the majority of the learners find Vee diagramming to be an enriching and a positive tool in helping them to understand the concept of force as well as assists them to store information for longer periods in their memory.

Most of the students that were interviewed found Vee diagramming to be a useful intellectual tool. The following excerpts are representative of some of the learners' views about Vee diagramming:

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S_1: When my teacher explains the work and she gives us the pages to learn, I just take out the key words and construct my own concepts and make more of it. It makes learning easier.

S_4: It is good I like it. It is easier to learn notes on my doing and my understanding that you have made yourself.

The responses imply that Vee diagramming positively influenced these learners, although the statistical analysis does not provide a definitive picture on how this instructional tool helped them. In pursuit of further analysis, possible effects of Vee diagramming in terms of gender and language were examined. The outcomes of this analysis are presented in the sections that follow.

4.9 Gender

Gender is a fundamental attribute in most cultures. A genderless identity does not exist. According to Sjoberg and Imsa (1988) gender is generally woven into a social rule that regulates social relationships between people, with same sex relationships and heterogeneous relationships. Girls are cautious not to offend the invisible rules of the female culture. Gender code means seeking approval to confirm personal identity that belongs to the female peer group. Kahle (1988) argues that science in most cultures is socially defined as a male domain. Sjoberg and Imsa (1988) argue further that boys choose science to prove their manhood as opposed to girls. Girls on the other hand may experience sanctions (or rejection) from their female group if they choose science. Therefore, the way in which learners are socialized in their socio-cultural roles can determine their behaviour in the classroom, as well as their roles in the learning environment. Table 4.9 below indicates the analysis of the pre and post-test scores of the test instrument based on gender.

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Table 4.9: Pre-test and Posttest scores on the COFT according to gender.

Group	C_1-group				E-group				C_2-group	
	Pre-test		Post-test		Pre-test		Post-test		Post-test	
Gender	M	SD	M	SD	M	SD	M	SD	M	SD
Male	7.69	5.20	7.63	5.20	7.58	5.12	9.10	5.62	7.66	4.70
Female	7.21	4.33	7.20	4.33	7.13	4.21	10.42	5.79	11.30	5.30
t-value	1.39		0.22		0.25		0.57		6.38	

NB: C_1-group not exposed to Vee diagramming.

E-group and C_2-group exposed to Vee diagramming.

According to the data (see Table 4.9) no statistically significant difference exists between the two groups (C_1 and E group respectively) because t-calc < t-crit. The mean score of the control group two (C_2) at the post-test stage in terms of gender is statistically significant, i.e. t-calc 6.38 > t-crit 1.71 ($p = 0.05$, $df = 23$). In the pre-test, the boys had a higher score than the girls but this result was reversed in the post-test. The reason for this relative improvement in the performance of the girls cannot be explained explicitly at this exploratory stage of the study. Further investigation and close up interview might provide a better insight into the phenomena responsible for the reversed pattern of performance. It is also note worthy that while the boys' achievement at the post-test decreased that of the girls increased.

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4.10 Language

South Africa has always been a nation of enormous linguistic diversity. In its constitution eleven languages are officially recognized. Despite this, only English and Afrikaans are used as the medium of instruction in higher institutions. Meanwhile, the home language of the majority is ignored. The consequence is that the bulk of students are deficient in the language they need to study in higher institutions (Rosenthal, 1995). The language of

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instruction plays a very important role in the teaching and learning of science. If teachers communicate in a language that is not understandable to learners, then the learners will not grasp what is taught. The policy of many a school to practise bilingualism has not helped the situation either. The common scenario is a second language teacher (e.g. an Afrikaans teacher) still struggling to master English confronted with second language learners who neither speak the language of the teacher nor are able to communicate fluently in basic English.

According to Kulkarni (1988), language is an important factor in the teaching and learning of science. As stated earlier, learners experience great difficulty in absorbing scientific concepts because of their inability to differentiate between the everyday notion and the scientific meaning (Garcia, 1984). Likewise, the acquisition of language is strongly dependent on the culture of individuals (Ogunniyi, 1988).

About 50% of the learners in the pre-test group were Afrikaans first language users and 50% were English first language users. During the interviews and classroom discussions, it was found that most of the English group spoke English only during instruction time.

Here are some of the responses of the learners when they were asked during the interviews what language they speak at home:

> S_1: I speak Afrikaans at home and English at school
>
> S_2: I speak only English during lessons and Afrikaans during breaks and at home.

S_4 and S_5 were asked when they started to speak English. Here are their responses:

> S_4: I started to speak English since grade 5
>
> S_5: I speak English since the start of pre-school

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Table 4.10: Pre-and Post-test results of grade seven learners based on language.

Groups	Pre-test		Post-test		
	Mean	SD	Mean	SD	t-test
E	7.20	1.98	8.84	5.82	-1.62
C_2	-	-	9.20	5.56	
C_1	7.76	2.05	7.30	4.69	- 0.39

A comparison of the performances of English and Afrikaans first language users is found in Table 4.10 above. The overall performance of the learners was very poor due to a low mean score. The results indicate that the Afrikaans group performed slightly better than the English group at both the pre-and post-test stage. A t-value greater than 1.68 is needed to reject the null hypothesis, suggesting no statistical significance. However, the null hypothesis could not be rejected suggesting no statistical significance. A t-value of -1.62 and 0.39 for the experimental and true control group (C_1) respectively confirmed the result. The academic performance of learners can be boosted if the language is properly grasped. The technical aspect of the science language creates a barrier to learning because it is different from the language they speak at home. It can be concluded that the learners experienced great difficulty in comprehending the concepts. The learning of science requires ways of talking and thinking acceptable to the scientific community. According to Rosenthal (1995) the learning of science in a second language is likely to encounter language problems. Hence, the reason for the better performance of the Afrikaans group can be due to various reasons: e.g. parental influence, motivation, attitude or the learners' understanding and depth of their pre-existent knowledge of force due to the supportive influence of their language, etc. However, this requires further investigation.

The home language of most learners that participated in this study is Afrikaans. Although the instruction was given in English learners were given the freedom to communicate in their mother tongue to say what they would like to say. Abstract science concepts such as mass, weight and gravity were explained in the learners' mother tongue, because some complained how different it was from their everyday understanding of the concept. The switch to the mother tongue helped some learners tremendously in comprehending

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abstract concepts that were foreign to them. Ogunniyi (1986) contends that learners who use their second language are likely to encounter language problems. Most of the learners claimed that they experienced difficulty in understanding certain concepts. Concepts such as gravity and mass are abstract and foreign to them. Kilfoil (1999) contends that linguistically weak learners are slow learners and that this results in alienating them from school science.

In this study, it was found that the learners failed to abstract the essential issues from the questions. It was also found that their vocabulary is very poor. Kulkarin (1988) found that learners from high poverty backgrounds enter school with a disadvantage, due to their restricted speech ability. According to Luthi (1969) learners with a limited or poor vocabulary develop comprehension difficulties. This normally results in insensible statements being made by the learners. When the learners were asked in the COFT to explain the concept of mass, a learner argued that, "it is a mass soogaar", other learners referred to it as a "heavy or light thing". When an attempt was made to teach the learners different or new words they showed an attitude of being bored.

According to Rollnick and Rutherford (1998) children develop a language for school and a language for home just like they have a uniform for school and a uniform for home. The meaning for everyday discourse is different from school science. Modern science has been developed in largely Western countries and hence, its thought forms, concepts and languages are consonant with the language of such societies.

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As much as possible instruction in science should be done in a learner's mother tongue. It has been found that the performance of learners in science is appreciably improved if the material is presented in their mother tongue (Ogunniyi, 1988, Rollnick and Rutherford, 1998), in that it is easier to understand and more enriching for learners. However, when it is not possible to teach a learner in his/her mother tongue then the second language in which the concepts are taught must be simplified to enable to learner grasp the content in question as well as ensure that he/she is not alienated from what is being conveyed to him/her.

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4.11 Discussion of results

A comprehensive review of the literature indicates that most learners enter the science classroom with all kinds of ideas and interpretations about natural phenomena (Ogunniyi, 1999; Aikenhead, 1996). These ideas are formed as a result of their experiences with the physical world, by talking with other people and through the media (Driver, Guesne and Tiberghien, 1985). According to Driver and Erickson (1983), learners internalize these experiences and construct their own meaning from them. Such ideas persist even if it is not consistent with the explanation of the teacher. It seems that the ideas, opinions and views of learners are totally ignored in the teaching and learning of science. The views and opinions of the teacher are regarded as superior to those of the learners. This is not surprising because the society from which these learners come from has taught them to respect the wisdom and authority of their elders, and in this case, their teachers. Such a perspective is not likely to encourage learners' inquisitive and questioning attitudes. In this regard, the authoritarian behaviours of teachers tend to discourage learners from asking questions to clear their doubts. They will rather ask one another and try to understand things they do not understand or remain silent with their problem if they do not find someone to help them. The reason why they do not ask their teacher in the classroom is either because they are afraid of their teacher or they do not want to be ridiculed by their mates. Most of the learners in this study held views that are contrary to that of school science. This is probably one of the factors that hindered their understanding of force and associated concepts. A wide variety of terms have been used to describe these ideas and beliefs they hold about the world around them. Some researchers refer to them as "children science", "alternative frameworks", "misconceptions", "naïve conceptions", etc (Driver and Erickson, 1983).

To Emereole (1998) the term misconception implies "mistake" or wrong response. A misconception devalues the correctiveness of an idea/belief and is perceived by the individual who constructed it. He argues further that it is seen by learners to be an appropriate interpretation of experiences that results from a logical approach to making sense of the world. Researchers all over the world have shown that learners hold a variety

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of misconceptions about force (Gunstone and Watts, 1985; Adams 2002; Dekker and Thijs, 1998). These ideas are held tenaciously and are contrary to valuable scientific conceptions. Their views are consistent with the social definitions of the term.

In this study the following misconceptions were evident:

- 28% in the experimental group and 48% in the control group respectively at the pre-test stage used the word force in an incorrect manner. Only four percent in the experimental group held a sound understanding about the concept as opposed to none in the control group.

- About 42% in the C_1 group, 32% in the experimental group and 24% in C_2 group held misconceptions about force at the post-test stage. A considerable number referred to force as strength, power. Other views expressed by the learners include phrases like: "force someone to go to the shop" or "to rape a female", etc.

- Again 50% in the experimental group and 20% in the control group held all kind of misconceptions. Their answers were vague, inappropriate and riddled with words with multiple meaning. A total of 27% in the experimental group and 23% in the control group did not attempt to answer the questions on mass and weight and left the spaces unanswered while 4% and 41% in the experimental and control group displayed no understanding.

- At the post-test stage, 28% in the E-group, 24% in the C_2-group and 48% in the C_1-group thought that mass and weight is the same concept with the same meaning. To them weight is the measurement taken on a scale. They referred to an individual's mass as his/her weight. They referred to mass as something heavy or light. A total of 48% of the learners used the word weight when they should have used the word mass.

- 42% in the C_1-group, 28% in the experimental group and 24% in the C_2-group held an incorrect conception of gravity at the post-test stage. Eight percent in the C_2-group, four percent in the experimental group and none in the C_1-group displayed a sound understanding of gravity. To these learners gravity is when objects fall to the ground

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by mistake. Some argued that things cannot stay in the air. A considerable number used the phrase "fall to the ground "rather than gravity. They confused the term with concepts related to observations made in the real world with the scientific concepts needed for explanations

The goal of this study was to measure the effect of Vee diagramming on the learners conceptual understanding of force as well ameliorate such misconceptions using this instructional tool. Although the E and C_2 (i.e. the group exposed to treatment) obtained higher mean scores than the C_1 (i.e. the group not exposed to treatment) at the post-test the findings of this study have not shown clearly how effective Vee diagramming is, in enhancing the learners' conceptions of force. Hence, while Vee diagramming seemed to enhance the E and C_2 learners' understanding of force (see Table 4.4) its overall advantage over traditional instruction has not been convincingly demonstrated. Perhaps the learners would require longer exposure to the former before its effect is clearly seen. However, the findings of this study have not been able to confirm convincingly claims in earlier studies that Vee diagramming necessarily enhances conceptual understanding (Novak et.al., 1983; Novak and Gowin, 1984; Henize-Fry and Novak, 1990). According to Novak and Gowin (1984) learners with a positive perception of the instructional approach and a positive attitude towards science will develop a deeper appreciation and understanding of science and consequently, achieve more.

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The learners claimed that the method they used to learn about force was new to them. Since their regular physical science class was merely theoretical in nature, they were mostly passive learners. The practical part of the lessons was foreign to them. They performed experiments and were encouraged to discuss and report the findings. In presenting the lesson to them 86% of all learners exposed to the treatment agreed that Vee diagramming helped them to understand the concepts easier. However, the main difficulty learners had in understanding the topic was perhaps the complex technical language they were exposed to when studying the concept. According to Aikenhead and Jegede (1999) learners are alienated from school science as a result of language inadequacies, resulting in them demonstrating work-avoidant goal orientation. Learners who display work-avoidant behaviour complete homework and assignments without

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having a meaningful understanding of the content. They complete assignments without working hard enough through them. They devise clever ways to finish assignments and homework given to them. It can, therefore, be concluded that although they liked the new instructional approach, their poor language skill in English prevented them from developing a valid understanding of force.

The results of this study which are consistent with earlier results in the area include:

- Learners entered the science classroom with already held explanatory views about scientific phenomena. These views are idiosyncratic interpretations of their experiences and are very often in sharp contrast with the views taught in the science classroom.

- The views that the learners hold are not always consistent with the expectation of the national curriculum.

- Learners' views about various phenomena are not easily replaced. For example 70% of the learners believed that weight is the same as mass.

At a very young age learners have ideas about things and these ideas play a role in the learning process. Learners interact with their environment through socio-cultural ways of thinking and imagining. The concepts that learners have about natural phenomena are socially constructed. Learners bring to class their own ways of looking at the world, and these ways are representative of not only their social and cultural environment but also their physico-chemical and biological environment. According to Driver, Guesne and Tiberghien (1985) what children are capable of learning depends on two things: 1) what they have in their heads and 2) the learning context in which they find themselves.

Ausubel (1968) contends that the most important thing to consider in the learning environment is to find out where the learners are before the commencement of the new lesson. If the pre-existent ideas of the learners are known, then these ideas can be challenged with ideas directly provoking them to consider their ideas. Science teaching

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should strive to extract the pre-existent ideas of learners rather than adding new information. For, example many learners come to class with the idea that heavier objects fall faster to the ground than lighter objects. When this is discussed in the science classroom by means of practical demonstrations, the learners might discover that the acceleration of objects of different weights and sizes in a gravitational field is not dependent on weight and that all objects whether heavy or light fall to the ground at the same acceleration.

This type of problem alluded to in the above paragraph creates cognitive conflict. This finding about the relationship between weight and gravity is consistent with a study done by Gunstone (1988). The meaning constructed by learners is not always in harmony with the scientific viewpoint. Therefore, knowledge cannot be directly transmitted from the mind of the teacher to the mind of the learner, since each learner creates his/her own understanding. Driver (1988) argues that learners are active participants and constructors of their own learning. The constructivists embrace the ideas and viewpoints of the learner in the teaching and learning environment. Driver cited by Fensham (1988) argues that learners construct mental models from their environment. New experiences are interpreted and understood in relation to existing mental models. Recognition of learners' prior knowledge helps teachers to understand better why they cannot assume that their explanations or demonstrations will be interpreted by learners in ways in which they have intended (Taylor, 1997). Science instruction that values the prior knowledge of learners sets out to demonstrate the inadequacies of their explanations of phenomena and supports learners to rethink their ideas.

As indicated earlier, in most South African classrooms including the schools where the study was conducted, teaching is still teacher-centered. Teachers spend a considerable amount of instruction time lecturing the learners. The rest of the lesson is spent by the learners copying down the notes from the blackboard while the teacher goes around ensuring that his/her notes are well copied down. Learners are not given opportunities to ask questions or to participate in the lesson. Learners who try to participate in class are ridiculed by the teacher as talkative or inattentive. During group discussions and interviews some learners claimed that their teacher did not encourage them to participate

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in class. When the learners were asked why they did not participate in class a learner asserted that:

> "Some learners are shy, others are afraid and scared of the teacher"

A learner pointed out that some teachers made comments like "nonsense", what type of question is that?" Other learners indicated that the attitude of their teachers towards learners' questions was very discouraging. In a traditional science classroom learners are seen as empty vessels to be filled with information from the teacher. The prior knowledge and ideas of learners are totally ignored during such lessons. As a result of this, learners' misconceptions go unchallenged. Driver, Guesne and Tiberghien (1985) argue further that where the teacher knows the ideas of his/her learners, activities can be structured or suggested that challenge such ideas. They claim that challenging learners' existing ideas may help such learners to reconstruct their intellectual faculties. Learning in science should therefore, be seen as restructuring of existing ideas rather than merely adding information to existing knowledge).

4.12 Summary

The learners' understanding about the concept of force was analyzed and discussed against five different levels of understanding ranging from "no response"," no understanding"," misconceptions", "partial understanding" to "sound understanding" . The overall performance of the learners exposed to the treatment at the post-test was slightly better than at the pre-test. In the pre-test the results ranged between 0 and 18 and at the post-test between 0 and 23. There was also a mean gain of 1.64 by learners exposed to Vee diagramming. The mean score of those not exposed to Vee diagramming remained basically the same at both the pre-and post-test stage.

The null hypothesis suggesting that no significant difference exists between the learners exposed to Vee diagramming and those not so exposed could not be rejected (t-calc < t-crit). Also, the null hypothesis suggesting that no significant difference exists between

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groups based on language and gender could not be rejected either due to the fact that t-values were less than the t-critical.

In conclusion, the instruction involved the use of Vee diagramming which did not seem to influence the learners in a significant way. This of course, is not the same as stating that the use of Vee diagramming has been a wasteful effort considering the greater mean gains by both the E and C_2 groups exposed to it. Rather, it is to say that though Vee diagramming had some positive impact on the learners exposed to it, the effect has not been as significant as was expected. Perhaps the short duration of the study (due to constraints of time allowed for the exercise), the newness of the instructional approach compared to what the learners were used to and other extraneous factors have contributed to the overall beclouding of the outcomes. In the next chapter, effort will be made to highlight the major findings of the study and their implications for curriculum developments and instructional practice.

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CHAPTER 5

CONCLUSION AND IMPLICATIONS

5.1 Overview

This study attempted to determine the relative effect of Vee diagramming on grade seven learners' conceptions of force. From the analysis of the results the following conclusions have been reached:

- At the pre-test stage 32% in the experimental group and 21% in the control group held a sound understanding about the concept of force. A total of 16% in the experimental group and 40% in the control group held all kinds of misconceptions, while 13% and 10% in the experimental and control group respectively left the questions on force unanswered.

- At the post-test stage 42% in the C_1 group, 32% in the E-group and 24% in C_2 group held misconceptions about force. Another 30% in the E-group, 48% in the C_1 group and 36% in the C_2 group had no understanding. Only 12% in the C_2 group, eight percent in the E-group and four percent in the C_1 group held a sound understanding about force.

- At the pre-test stage only three percent in the experimental group and one percent in the control group could distinguish between mass and weight. About 50% and 41% respectively in the experimental and control group held misconceptions about the concepts. They suggested that mass and weight is exactly the same concept. They were unable to explain any of the two terms in a clear and concise manner.

- At the post-test 20% in the E group, 48% in the C_1 group and 36% in the C_2 group displayed no understanding about mass and weight by leaving the answer sheet blank. Twelve percent in the experimental group, 16% in the C_2-group and

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eight percent in the C_1-group displayed a sound understanding about mass and weight.

- At the pre-test stage only five percent in the control group held a sound understanding about gravity as opposed to none in the experimental group. Another 33% in the experimental group and 15% in the control group left the questions on gravity unanswered, while 32% and 49% in the experimental and control group respectively held illogical or incorrect conceptions about gravity.

- At the post-test stage 42% in the C_1-group, 28% in the experimental group and 24% in the C_2-group held an incorrect conception of gravity. Eight percent in the C_2-group, four percent in the experimental group and none in the C_1-group displayed a sound understanding of gravity. These learners argued that gravity exists because of the nature of objects to fall to the ground. They developed this misconception probably because of their everyday experiences with falling objects.

The findings of the study confirm most of the earlier findings in the area, namely that learners hold conceptions quite distinctive from school science (Driver and Erickson, 1983; Ogunniyi, 1999, 2001 and Aikenhead, 1996)

The pieces of evidence that have emerged from the study indicate that the learners had a poor conceptual understanding of force and associated concepts such as mass, weight and gravity. Some referred to force as strength, power, and masculinity while others argued that force is when someone is forced to do something against his/her will. They seem to confuse the term with their everyday meaning of the word. These misconceptions also referred to as "naïve conceptions" (e.g. Erickson and Driver, 1983) were already identified by other researchers (e.g. Adams, 2003; Ogunniyi and Fadkudze, 2002; Gunstone, 1988). The study investigated various factors which are associated with the learners understanding of force. Some of the underlying factors include attitude, gender

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and language on the learners' conceptions of force. Other difficulties seem to be associated with general learning problems and the way science is presented in the classroom.

A plethora of studies using intervention strategies such as Vee diagramming or Concept mapping have shown a significant shift in the learners' belief in favour of school science (e.g. Novak, et al, 1983; Novak and Gowin, 1984; Henize-Fry and Novak, 1990). The main objective of this study was the use of Vee diagramming to ameliorate the various misconceptions learners hold about force. However, the findings of this study indicate that this goal has not been fully achieved. Although the groups exposed to Vee diagramming (E and C_2) obtained higher mean scores than the C_1 group probably as a result of the Vee diagramming to which they were exposed, the ANOVA results ($0.61 < 3.15$ i.e. $F(2,72) = 3.15$ at $p < 0.05$) indicate no statistical significance. The difference in performance cannot be explained at this exploratory stage, perhaps if the learners were exposed for a longer period, the Vee diagramming instructional approach might have proved to be more effective, but this require further investigation. An analysis of the results in chapter 4 also reveals how the learners' language competence seem to affect their understanding of force.

The poor language skill of most of the learners affected their understanding of force negatively. An analysis of the findings on the COFT indicates that their proficiency in the English language is relatively weak. This was confirmed when some learners complained about how difficult it was to answer questions demanding long answers, compared to the one word answers such as yes, no, agree, disagree where the response rate was 100%. The formulation and expression of their own words to questions was problematic. Another hindrance to the learners' understanding of force could be the abstract nature of the concept when situated in a scientific context. The learners complained about the difficult terminologies and explanations called for in science. A good grasp of the language of science is always a crucial perquisite for the conceptualization and communication of what is taught or learned in science or any school subject for that matter (Ausubel, 1968).

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Another barrier hindering learners' understanding of science concepts (force inclusive) is the way science is presented in the classroom. The methodology used in the study was new to them. The learners came from a background where they could be ridiculed by the teacher or their classmates if they made mistakes. Other factors that might have influenced the learners' understanding of force are gender and attitude. As indicated in chapter 4, the learners' performance on the basis of gender was generally poor as shown by low mean scores obtained by the learners. At the pretest stage the boys performed better than the girls but at the post-test stage the result was reversed. The t-values at the pre-test were statistically insignificant, and at the posttest, control group two displayed a statistical significance. The study also showed that the attitude of the teacher in science also affected the performance of learners.

According to Leach and Scott (2000) children live within a community that has its own "common sense" or "everyday" ways of talking and thinking about natural phenomena. Ogunniyi (1988) argues that their views are embedded in their cultural framework. Although they have a poor conceptual understanding of force, nevertheless they have some view about the concept, though in a disparate and inconsistent manner. These views are based largely on commonsensical knowledge. Strauss (cited Driver, 1988) argues that our common-sensical view is spontaneous and universal. Science places great emphasis on explanations to a wide variety of situations, which is contrary to the common sense of learners. Emereole (1998) contends that commonsensical notions could constitute a barrier to the learning of science. The learners do not seem to care whether their views are incompatible with the different situations involving science. Learners copy their notes from their notebooks and in the examination they recall their notes which they have memorized. The analysis shows that learners struggle to read and engage with the physics textbooks to gain a deeper insight into the content to be learned. However, the complex and unfriendly language in the textbooks is simply to blame for learners resorting to rote learning. Science to them is a memorization-oriented subject. Learners only respond in terms of the desired outcomes of the teacher and when they leave the science classroom they cleave unto their own belief. The various excerpts cited in chapter 4 have further

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shown that, though the learners' conceptions of force might be inadequate, they nevertheless show that they did not come into the classroom as 'empty vessels'.

Constructivists argue that learners' ideas about various phenomena are distinctive from that of school science. According to Driver and Erickson (1983) the poor performance of learners in science occurs as a result of their inability to alter their ideas in favour of the scientific conception. They argued and suggested further the following approach as necessary to attain conceptual change among the learners:

1) Establishment of detailed and more fruitful differences between the learners' belief and the scientific idea.

2) The views of learners should be observed over time instead of what they refers to as "map shot models"

3) Attempting to enhance change via an intervention or meaningful learning.

Vee diagramming and concept mapping, used in this study are intervention strategies designed to render science in a meaningful manner to learners who normally need concrete props to conceptualize the abstract language of science (Novak and Gowin, 1984). Other strategies include: talking science, reading, writing and group discussions. The view of the learner as the architect of his/her own knowledge is a broadly held assumption (Driver and Erickson, 1988). This points out that, if one wants to understand this body of knowledge, provision must be made to include their views and ideas in the teaching and learning process. Science must be presented to them in a debatable and tentative manner. Failure to do so will result in the classroom becoming enormously complex.

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5.2 Implications

The results of this study have implications in at least two specific areas of science education:

- Curriculum
- Instruction

Each of the above implications is discussed briefly in the sections that follow.

5.2.1 Implication for curriculum

The findings in this study might indicate that many of the learners have an intuitive notion about force. But as far as a sound understanding is concerned much confusion is evident. Force is a very complex concept and the information provided in the textbooks seems to reinforce this confusion. For example, some textbooks only define force as a push or pull action, without explain that pushing/pulling is the result of humans moving objects. No in-depth understanding about the concept is revealed to the learners. Learners experienced great difficulty in distinguishing between mass and weight. The most common type of response (70%) is that there is no difference between the two concepts. However, curriculum planners, authors of textbooks, and teaching programmes do not seem to take cognizance of these difficulties. They assume that learners have already acquired these notions in question (Tiberghien, 1988).

In the South African context, the learning of science is rooted in the familiar "tabula rasa" metaphor also referred to by Gunstone and White (1985) as a "hydraulic model" of learning. They view the transition of knowledge from teachers to empty headed learners. The knowledge transfer of science is like water being poured from a jug into an empty glass. The learners come to school to learn outcomes i.e., to emerge from school with all of the predetermined objectives of the curriculum. Success in such a system means to exist with the correct answers to the questions posed by the curriculum. This is an acceptable outcome in such a system. The learners that fail to do so are easily and systematically "recycled back" through the experience by having to repeat the grade until

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success is achieved or until the learner drops out of school. It is not the experience of the learners that is of importance, but it is the effect of the curriculum upon the learner that matters. For years, the phenomenological world of the learner has been ignored (Gilbert and Watts, 1983). Meaningful learning is opposed to this type of learning model. It embraces the ideas that the learners bring to class. The idea of meaningful learning is that learners acquire new knowledge more easily when they are able to relate it to existing ideas or to a language that is understandable to them.

Within the constructivist epistemology learners' experience of school science is often viewed not only in terms of ultimate effects of the curriculum upon the learner but in terms of the learners' active involvement with the curriculum. This study has shown the complexities of learners' ideas with the science curriculum. A significant number of the learners in this study held identical ideas about mass, weight and gravity before instruction. Although all the learners in the respective groups exposed to Vee diagramming received the same instruction only 30% at the post-test changed their ideas. These findings are evident even when the incorrect notion about the topic is explicitly addressed. The following are of importance to the curriculum:

- Teachers need extensive training with regard to the concept of force, to achieve the aims of the General Science Curriculum (Adams, 2003)

- It is advisable for the Science Curriculum Panel of the Department of Education to encourage teachers to participate in curriculum development. Teachers are aware of the difficulties in understanding the concept of force learners are faced with.

- Textbook authors have to work collaboratively with the Science Panel of the Department of Education and play their roles in the development of the science curriculum.

- Science textbooks should be written in a language that is accessible to the majority of the learners.

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- Instructional guidance in textbooks in the form of activities to be done must be presented to the learners in the simplest way possible.

- Concepts of force and associated concepts such as mass, weight and gravity must be carefully revised and prepared to fit the appropriate grades of learners.

- Curriculum planners should build on the learners' ideas in science being cognizant of the socio-cultural environment of the learners.

- Presentation of science (both in classroom and textbooks) must promote learners' thinking skills.

School science contributes significantly to human knowledge. Knowledge in science is a socially powerful way of knowing about natural objects and phenomena (Fensham, 1988). This implies that knowledge included in the curriculum should be relevant, appropriate and recognizable by learners. It should be amendable to a pedagogy that makes school science attractive, exciting and a rewarding experience. Another issue is the need to introduce networking into the classroom. According to Fensham (1988) networking implies that teachers need to be brought into association with each other and curriculum planners for the sharing of ideas, information and experience.

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5.2.2 Implication for instruction

The results show the difficulties that the learners involved in the study experienced in acquiring the scientific notion of force. They could not explain the concept of force or the concepts that are used to describe it neither could they explain the relationships between the direction of motion and the direction of force. However, typical teaching programmes do not take these difficulties into account. The learners' ideas, cultural background and experiences with the environment are ignored in the science classroom, as a result of the

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pressure applied by the Education Department, to complete the sallybus. Resulting in teachers assuming that learners already acquired these notions in question.

More appropriate teaching that might help learners to acquire these notions and to overcome these difficulties identified should include the following:

- Learning about force should be introduced to learners in a way that will help them to view force as being the result of dynamic, moving things (humans or moving balls, etc.)

- Several activities with moving objects and also static situations such as a book lying on a table need to be demonstrated and explained properly. In this example, the reconciliation of the learners' existing views of force with the scientific view must help the learners understand that the situation is not a static one. At the same time, the concept of gravity can also be introduced.

- Learners can learn to weigh different objects on a scale to familiarize themselves with the concept of mass. They can also be asked to determine their body masses. They can then be asked to compare the different masses with each other. They should be instructed on how to determine the weight from the mass and to see for themselves the prerequisite for weight. Demonstrating the difference between mass, weight and their relation to force is opposite at this stage.

- Several demonstrations and activities with gravity, explaining the relationship of gravity to force are vital to learners' conceptual understanding of these concepts.

- Application to real life situations in the world of work or at home are crucial to learners' understanding of force.

The introduction of force gives learners a number of problems for several reasons. Very often this notion is introduced before understanding the views or ideas of force held by learners. Normally their views are at odds with the laws and theories of physics. A

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careful analysis of their views should be made and looked into before the scientific viewpoint of the concept is introduced in order to resolve possible cognitive conflict that might exist. It is not enough for learners to become dissatisfied with the views they hold. If the new material presented to the learner is to replace the existing information, the new view must be plausible, intelligent and fruitful (Chiu, Chou and Lui, 2002). However, according to Gunstone and White (2001) a concept may be plausible, intelligent and fruitful and yet not accepted by learners because it does not quite coincide with their daily experiences or intellectual interest. This implies that science instruction must go beyond the creation of cognitive conflicts among learners but ensure that such conflicts encourage them to find a way to accommodate the new experience. Learners would easily give up ideas they have developed over the years and found to be fruitful for new ideas that have not been tested through experience (see Cobern, 1994).

5.3 Limitations of the study

- Various constraints did not allow the investigator to conduct the study beyond four weeks. The need to implement Vee diagramming as a method of instruction over a longer duration has been pointed out in a number of studies (e.g. see Ebenezer and Connor, 1998). It takes at least one or two weeks before learners get used to this new teaching-learning approach. However, in an examination driven curriculum, as was the case encountered in this study, very little could be done to extend the study beyond four weeks. Therefore it will be advisable to repeat the study, but more time must be allocated for the intervention.

- As indicated earlier, the study was limited to only two schools. Time and financial constraints did not permit a wider coverage. For instance, the Department of Education does not give in-service teachers studying in higher institutions more than 80 official hours for professional development. An alternative would be to conduct the study after school hours or at weekends but again this proved

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impossible during the period of this study. Despite these limitations, however, concerned effort was made to utilize time available to carry out the study.

5.4 Recommendation for further research

In order to ensure the quality and effectiveness of science education in schools:

- It will be useful to find out teachers' understanding of the concept of force. Such a study might help to identify how strong or weak are the teachers' conceptions of force and how they can be helped to upgrade their conceptual understanding of the concept, as well as gain instructional skills and confidence to teach the concept to their learners.

- Further studies carried out over a longer duration seem warranted to ascertain the efficacy or otherwise of Vee diagramming as an instructional tool.

This study sought to determine the ideas held by grade 7 learners with regard to the Newtonian concept of force. It attempted to remedy the inaccurate conceptions held by the learners through the use of Vee diagramming. The findings of this study were analyzed against the research questions and discussed in the context of the extant literature. The conclusions and recommendations of this study might prove to be informative and useful to curriculum developers, textbook authors and teachers in their attempts to identify the weaknesses and strengths of current material and learners' understanding of an important scientific concept, force.

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REFERENCES

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References

Abrahams, M.R., Grzybowski, E.B., Renner, T.W. and Marek, E.A. (1992). Understanding and misunderstandings of grade eight's of five chemistry concepts found in textbooks. Journal of Research in Science Education, 29 (2): 105-120.

Abrahams, M.R., and Williamson, V.M. (1994). A cross age study of the understanding of five chemistry concepts. In Kyle, W. Jr. (Ed). Journal of Research in Science Teaching, 31 (2): 147-165.

Adams, S. (2003). Worldview presuppositions and conceptions of force held by junior secondary school science students. Doctoral thesis, University of the Western Cape.

Adams, S. (1999). An analysis of border crossing between learners' life-world and school science. Journal of the South African Association of Research in Mathematics and Science Education, 3 (1): 14-21.

Aikenhead, G. (1996). Science education: Border crossing into the sub-culture of science. Studies in Science Education, 27, 1-27.

Aikenhead, G. and Jegede, O.J. (1999). Cross cultural science education: A cognitive explanation of a cultural phenomena. Journal of Research in Science Teaching 36 (3): 269-287.

Atheee, M. and Varjola. I. (1998). Students' understanding of chemical reactions. International Journal of Science Education, 20 (3): 305-316.

Ausubel, D. (1968). Educational psychology: A cognitive perspective. City University Press.

Ausubel, D., Novak, J.D. and Hunesian, R. (1978). Educational psychology: A cognitive perspective, 2nd edition. City University Press.

Barrass, R. (1982). A guide to better writing in course work and examination. Students must write. London, University Press.

Brewer, W.L. (1969). Factors affecting student achievement and change in a physical science survey course. In Boenig, R.W. (Eds). Research in Science Education. Teachers College Press.

http://etd.uwc.ac.za/

Browne, N. (1991). Science and technology in the early age: An equal oppertunies approach. Milton Keynes: Open University.

Brunner. J. (1996). Education and culture. Harvard: Cambridge University Press.

Chui, M.H., Chou C.C. and Liu, C.J. (2002). Dynamic processes of conceptual change: Analysis of constructing mental models of chemical equilibrium. Journal of Research in Science Teaching, 38 (8), 688-712.

Clement, J. (1982). Students preconceptions in introductory mechanics. American Journal of Physics 50, 66-71.

Cobern, W. (1994). Thinking about alternative constructions of science and mathematics education. A plenary presentation for the second annual Southern African Association for mathematics and science research conference. University of Durban-Westville, Durban, South Africa.

Cohen, R. and Manion, L. (1989). Research methods in education. London: Routledge.

Cross, M. and Chisholm, L. (1990). The roots of segregated schooling in the twentieth century South Africa. In M. Nkomo (ed). Pedagogy of domination: Towards a democratic education in South Africa. Trenton New Jersey, African World Press.

Dekker, P.J.J.M. and Thijs, G.D. (1998). Making use of students initial conceptions in developing the concept of force. Science Education Journal, 8 (1): 31- 51.

Driver, R. (1988). A constructivist approach to curriculum development. In Fensham, P. (Eds). Development and dilemmas in science education. London: Farmer Press.

Driver, R. (1989). Students' conceptions and the learning of science. International Journal of Science Education, 11, 481-489.

Driver, R. and Erickson, R. (1983) Theories in action: Some theoretical and empirical issues in the study of students conceptual frameworks in science. Studies in Science Education, 10, 37-60.

Driver, R., Guesne, E. and Tiberghien, A. (1985). Children's ideas and the learning of science. Milton Keynes: Open University Press.

Ebel, R.L (1969). What is the scientific attitude? In Boenig, R.W. (Eds). Research in Science Education. Teachers College Press.

UNIVERSITY of the WESTERN CAPE

Ebenezer, J.V. and Connor, S. (1998). Learning to teach science. New Jersey: Prentice Hall.

Emereole, H.U. (1998). World views portrayed by illiterate Botswana adults about common practices and phenomena. Journal of the South African Association of Research in Mathematics and Science Education, 2 (1): 61-71.

Esiobu, G.O., and Soyibo, K. (1994). Effect of concept mapping and Vee mappings under three learning modes on students cognitive achievement in ecology and genetics. In Kyle, W. Jr. (Ed). Journal of Research in Science Teaching, (32), 9: 971-995.

Fakudze, C.G. (2002). Border crossing: a case study of selected scientific and traditional woldview presuppositions among Swaziland high school students. Doctoral Thesis, University of the Western Cape.

Fakudze, C.G. and Ogunniyi, M.B. (2002) Border crossing the collateral theory and the contiguity hypothesis: A case study of Swazi high school students. A paper presented at South African Association of Research in Mathematics and Science Education, Mozambique.

Fensham, P., Gunstone, R. and White, R. (1994). The content of science: A constructivist approach to teaching and learning. London: Farmer Press.

Gilbert, J.K. and Watts, D.M. (1983). Concepts, misconceptions and alternative conceptions – Changing perspectives in science education. Studies in Science Education, 10, 61-98.

Goa, L. (1998). Cultural context of school science teaching and learning in the people's republic of China. Studies in Science Education, 82, (1): 1-13.

Gunstone, R.F. (1988). Learners in science education. In Fensham, P. (Eds). Development and dilemmas in science education. London: Taylor and Franscis Ltd.

Gunstone, R.F. and Watts, M. (1985). Force and motion. Children's ideas and the learning of science. Milton Keynes: Open University Press.

http://etd.uwc.ac.za/

Gunstone, R.F. and White, R. (2000). Goals, methods and achievement of research in science education. In R. Millar, J. Lead and J. Osborne. (eds). Improving science education: The contribution of research. Buckingham, Open University Press.

Halloun, I.A. and Hestenes, D. (1985). The initial knowledge state of college physics students. American Journal of Physics, 53 (11): 1043-1055.

Henize-Fry, J.A., and Novak, J.D. (1990) Concept mapping brings long term movement towards meaningful learning. Science Education, 74 (4): 461-472.

Hurd, P. (1998). Scientific literacy: New minds for a changing world. Science Education Journal, 2 (3): 407- 418.

Jackendoff, R. (1994). Patterns in the mind. Language and human nature. Basic Book.

Jegede, O.J. (1995a). Collateral learning and the eco-cultural paradigm in science and mathematics education. A paper presented at the third South African Association for Research in Mathamatics and Science Education Conference, Cape Town..

Jegede, O.J. (1995b). Traditional cosmology and collateral learning in non-western science classrooms. In M. Ogawa (Ed), Effects on traditional cosmology on science education. Ibaraki: Ibaraki University: 63-73.

Jegede, O.J. (1997). School science and development of scientific culture: A review of contemporary science education in Africa. International Journal of Science Education, 19 (1): 1-20.

Johnson, D.M .(1992). Approach to research in secondary language learning. London: Longman.

Johnstone, A.H. (1993). Why is science difficult to learn? Things are seldom what they seem. In D. Edwards, E. Scanlon and D. West. (eds)Teaching learning and assessment in science education. London: Open University Press.

Kallaway, P. (1984). Apartheid and education: The education of black South Africans. Johannesburg, Raven Press.

Keto, C.T. (1990). Pre-industrial education policy and practice in South Africa. In M. Nkomo (ed). Pedagogy of domination: Towards a democratic education in South Africa. Trenton New Jersey. African World Press.

Kuhn, T.S. (1970). Taking a closer look at the cloze procedure. Reading world, 29 12-18.

UNIVERSITY of the WESTERN CAPE

http://etd.uwc.ac.za/

Kulkarni, V.G. (1988). The role of language in science education. In Fensham, P.(Eds). Development and dilemmas in science education. London: Taylor and Franscis Ltd

Killfiol, W.R. (1999). The linguistic competence of science students. South-African Journal of Higher Education, 13 (1): 1011-3487.

Kuiper, J. (1998). Science and culture: The art of balancing. Journal of the South African Association for Research in Mathematics and Science Education, 2 (1): 21-32.

Kyle, W.C. (2002). Effect of poverty on urban school learners in the U.S.A. Seminar series: University of the Western Cape, School of mathematics and science education. Cape Town.

Leach, J. and Scott, P. (2000). Children's thinking, learning, teaching and constructivism. In M. Monk and J. Osborne (Eds). Good practice in science teaching. Buckingham: Open University Press: 41-55.

Lehman, J.D., Carter, C.O., and Kahle, J.B. (1982). Concept mapping, Vee diagramming and achievement: Results of a field study with black high school students. Journal of Research in Science Teaching, 27, 663-673.

Lewin, C.M. (1992), Science education developing countries. Issues and perspectives for planning. Open University Press.

Luthi, L.R. (1969). A case of reading comprehension difficulties in science materials. In Boenig, R.W. (Eds). Research in Science Education. Teachers College Press

McNally, D.W. (1973). Piaget education and teaching. London: The Harvester Press

McNaught, C. (1991). Learning science at interface between Zulu and English: A brief overview of research issues in this area. Paper delivered at a conference on Language, Thought and Culture, 2-4 April.

Ndagi, J.O. (1984). Essentials for research methodology for Nigerian educators. University Press Ltd.

Nenty, J.N. (2000). Relative influence of language on primary and secondary school pupils' performance in science and mathematics in Lesotho. Proceedings on mathematics, science and technology (MST). Education in the next millennium Roma, Lesotho.

http://etd.uwc.ac.za/

Nkomo, M. (1990). Pedagogy of domination: Towards a democratic education in South Africa. Trenton New Jersey, African World Press.

Novak, J.D (1990) Concept Mapping: A useful tool for science education. Journal of Research in Science Teaching, 27, 937-949.

Novak, J.D. and Godwin, D.B. (1984). Learning how to learn. New York: Cambridge University Press.

Novak, J.D., Gowin, D.B., Johansen, G.T. (1983) The use of concept mapping and Vee dagramming with junior high school science students. Science Education 67: 625-645.

Odom, A.L. and Kelly, P.V. (1998). Making learning meaningful. The Science Teacher, 65 (4): 33-37.

Ogawa, M. (1986). Towards a rationale of science education in a non-western society European Journal of Science Education, 8 (2): 113- 116.

Ogunniyi, M.B. (1978). Determinants of successful implementation of the integrated science program in Nigeria. Journal of the South African Association in Research of Mathematics and Science Education, 16 (2): 50-58

Ogunniyi, M.B. (1999). Understanding science concepts among grade 7-9 pupils in the Western Cape. Proceedings of the 7th SAARMSE Conference, Harare.

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

Ogunniyi, M.B. (1988). Adapting western science to traditional African culture. International Journal for Science Education, 10 (1): 1-9.

Ogunniyi, M.B. (1986). Teaching science in Africa. Ibadan: Salem Media (Nig) Ltd.

Ogunniyi, M.B. (1987). Conceptions of traditional cosmological ideas among literate and non-literate Nigerians. Journal of Research in Science Teaching, 24 (2): 107-117.

Ogunniyi, M.B. (2001). Border crossing between distinct worldviews. A seminar paper delivered at the school of mathematics and science education, University of the Western Cape.

Ogunniyi, M.B. (1997). Science education in a multi-cultural South-Africa. A report of an international scientific research program funded by Grant-in-Aid for scientific research, Ibaraki, Japan.

UNIVERSITY of the WESTERN CAPE

Ogunniyi, M.B. (1996). Multiculturalism and science education research in the new South Africa. Proceedings of the fifth annual meeting of the South African Association for Research in Mathematics and Science.

Ogunniyi, M.B, (2002). Border crossing into school science and the contiguity hypothesis. A Paper presented at NARST conference, New Orleans.

Ogunniyi, M.B. and Fakudze. C.G. (2002) Grade nine students conceptions of force, energy and power. A seminar series at the University of the Western Cape.

Ogunniyi, M.B. (1995). Worldview hypothesis and research in science education. In Hendrix, H. (Eds) proceedings, SAARMSE, Third annual meeting. Cape Town, South Africa: 613-624.

Ogunniyi, M.B. and Taale, K.D. (2004). Relative effect of a remedial instruction on grade seven learners' conceptions of heat, magnetism and electricity. African Research Mathematics, Science and Technology Education, 8 (1): 77-84.

Okebukola, P.A. (1990). Attaining meaningful learning of concepts in genetics and ecology: An examination of the potency of concept mapping. Journal of Research in Science Teaching, 27, 493-534.

Okebukola, P.A., and Jegede, O.J. (1988). Cognitive preference and learning mode as determinants of meaningful learning through concept mapping. Journal of Science Education, 74, 489-500.

Osborne, R. and Writtock, M. (1985). The generative learning model and its implications for science education. Studies in Science Education, 12, 59-87.

Poole, M.W. (1995). Believes and values in science education. Buckingham Philadelphia, Open University Press.

Popper, K.R. (1965). The logic of scientific discovery. New York: Harper Torchbook.

Sanders, D.H., Eng, R.J. and Murphy, F. (1985). Statistics a fresh approach. 3rd ed. McGraw Hill Book Company.

Schaeffer, R.L., Mendenhall, W. and Otto, L. (1986). Elementary survey sampling. New York: Academic Press.

Schuman, H. and Presser, S. (1981). Questions and answers in attitude surveys. New York: Academic Press.

UNIVERSITY of the WESTERN CAPE

Shepardson, D.P., and Moje, E.B. (1994). The impact of science demonstrations on childrens' understanding of air pressure. In Kyle, W.C. Jr. (Ed) Journal of Research in Science Teaching, 3 (31): 243-258.

Sjoberg, S. and Imsen, G. (1988). Gender and science education. In Fensham, P. (Eds). Development and dilemmas in science education. London: Taylor and Franscis Ltd

Solomon, J. (1987). Social influence on the construction of peoples' understanding of science. Studies in Science Education. 17, 44-59

Strevens, P. (1976). Problems of learning and teaching science through a foreign language. Studies in Science Education, 3, 55-68.

Ritchie, W. (1918). The history of the South African college, 1829-1918. Cape Town: Maskew Miller.

Rollnick, M. (1998). The influence of language on the second language teaching and learning of science. Cobern, W.W. (Eds), Socio-cultural perspectives on science education. Netherlands: Kluwer Academic Publishers: 121-137.

Rollnick, M., and Rutherford, M. (1996). The use of the mother tongue and English in the learning and expression of science concepts: A classroom based study. International Journal of Science Teaching, 18 (1): 91-110.

Rosenthal, J.W. (1995). Teaching science to language minority students. Multilingualism matters Ltd. Frankfurt Lodge.

Taylor, P.C. (1997). Constructivism: Value added. In Frash, B. and Tobin, K. (Eds) The international handbook science curriculum. Dordrecht, Netherlands: Kluwer Academic Press, 1-22.

Tharp, R.G. (1989). Psycho-cultural variables and constants. Effect on teaching and learning in schools. University of Hawaii.

Thijs, C.D. (1992). Evaluation on an introductory course on force considering students' pre-conceptions. Science Education, 76 (2): 155-174.

UNIVERSITY of the WESTERN CAPE

http://etd.uwc.ac.za/

Thijs, C.D., Dekker, P. and Smith, U. (1993). Research into the understanding of the Concept of force carried out in developing countries in co-operation with Research in Netherlands: Paper presented at the International Conference Science Education in Development countries. From Theory to Practice. Jerusalem, Israel, 3-8 January.

Vygotsky, L.S. (1978). Mind in society: The development of higher psychological processes. Cambridge, Harvard University Press.

Wandersee, J.H. (1990). Concept mapping and the carthography of cognition. Journal of Research in Science Teaching, 27, 923-936.

Western Cape Education Department. (1997). Outcomes Based Education: Policy Document for senior phase.

White, R.T. (1991). Learning in science viewed as personal construction. An Australian perspective. Northfield . J and Symington, D. (Eds). Monograph no. 3. Key Centre for School Science and Mathematics at Curtin University of Technology.

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APPENDICES

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Appendix A

General Ability Force Test (GAFT)

Instructions:

a) **Answer all the questions.**

b) **Answer your questions in full sentences (if asked to explain or describe).**

c) **Write your answers in the spaces provided.**

Question 1

Answer the following questions in full sentences.

1.1) Explain in your own words what your understanding of the term force is.

....

....

1.2) What is the difference between your mass and your weight?........................

....

....

1.3) Will your mass be same on the moon as on the earth?..................................

....

....

1.4) What is the units for mass?................

1.5) What is the units for weight?............

1.6) What is the units for force?................

1.7) Is there any relationship between the mass of an object and force? Explain.

....

....

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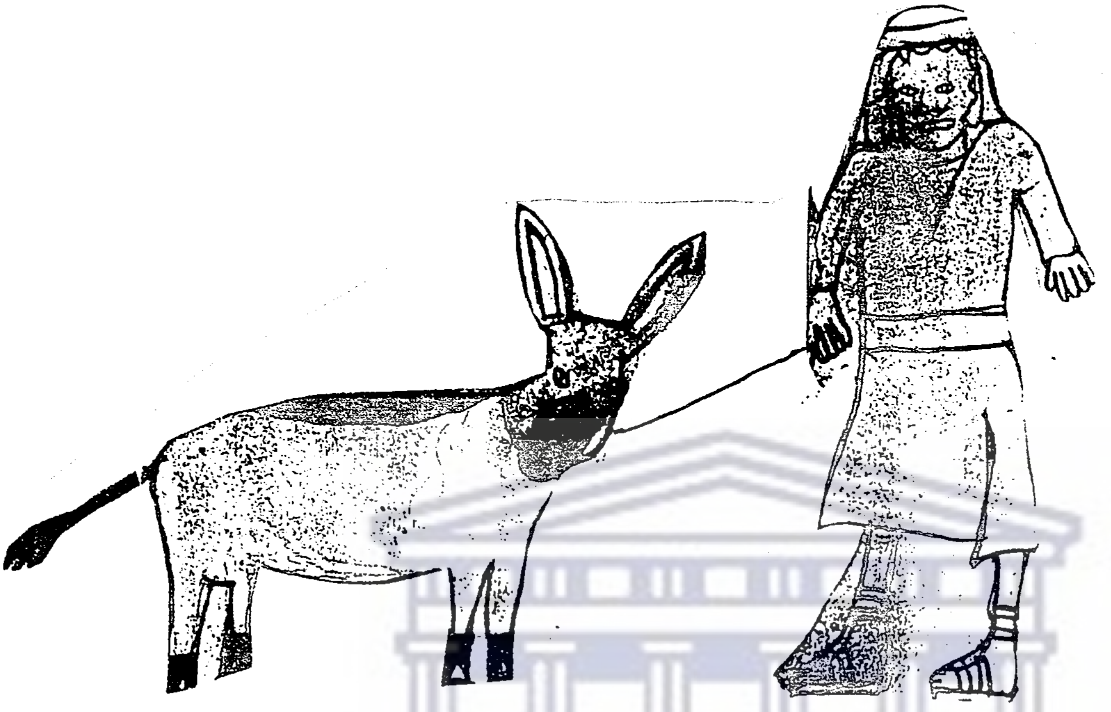
Question 2

Look at the diagram below and answer the questions that follow.



2.1) Describe in your own words what you see in the drawing...............

....

....

....

2.2) Is there any force present in the diagram that you can identify?..........

....

2.3) What do you think is the reason that there is no movement between the donkey and the boy?...

....

....

2.4) When an object shows no movement when a force is exerted on it, does it mean there is no force present? Explain in your own words............

....

....

....

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Appendix B

Concept of Force Test (COFT)

Instructions:

a) Answer all the questions.

b) Answer your questions in full sentences (if asked to explain).

Question 1

Choose the most suitable/correct answer that corresponds to its box.

1) Which of the following statements best describe a force?

   A. It is a push or a pull action

   B. A force is required to move any object from point A to point B.

   C. A boy pushing a wall.

   D. Your mother forces you to go to the shop.

A. A, B.

B. A, B and C.

C. All of the above.

D. None of the above.

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2) On the moon people…………………

A) Walk

B) Gallop

C) Swift

D) None of the above

3) The bigger the ……………, the bigger the force.

A. Weight

B. Mass

C. Size

D. None of the above

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Question 2

Siphiwe told his friends that his father is a very strong man, and that his father can pick up a huge truck with one hand.

a) Can you pick up a truck with one hand?

Yes ( ) No ( ).

Explain ……………………………………………………………………………………..

……………………………………………………………………………………………

……………………………………………………………………………………………

b) In your opinion, is Siphiwe's father really strong?

Yes ( ) No ( ).

Explain………………………………………………………………………………………

……………………………………………………………………………………………

c) Does the truck in the above text have a big or a small mass?.......................................

Explain…………………………………………………………………………………….

……………………………………………………………………………………………..

d) Explain in your words what is your understanding of the term mass…………………

……………………………………………………………………………………………..

……………………………………………………………………………………………..

e) Is there any difference between the terms mass and weight?..

……………………………………………………………………………………………..

f) Explain……………………………………………………………………………………..

……………………………………………………………………………………………

g) Is there any relationship between the mass of an object and force……………………

……………………………………………………………………………………………

……………………………………………………………………………………………

h) What is the units for mass?.................

i) What is the units for weight?...............

j) What is the units for force?................

k) Explain in your own words the term force?...

………………………………………………………………………………………………

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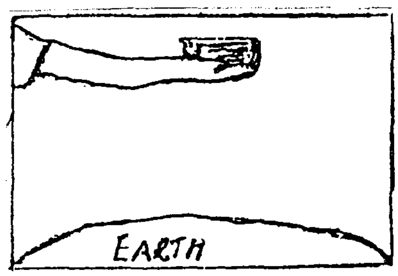
Question 3

Look at the diagram below and answer the question that follow.



a) Will the boys arm become tired, if he should hold the book for longer than 10 minutes in his outstretched arm?

Yes ( ) No ( )

b) Explain your answer...

....

....

c) Are there any forces present in the diagram?

Yes ( ) No ( )

d) Name the forces...

e) What will happen to the book if the drops it?...

f) Explain your answer...

....

Question 4

State whether you agree or disagree with the following statements.

4.1) The earth exerts a force on your body...............................

4.2) The force the earth exerts on your body is called the gravitational force................

4.3) There is no difference between the force on the earth and the force on the moon......

4.4) A force is applied when you refuse to do something against your will...............

4.5) Weight and mass has the same meaning.........................

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Appendix C

Student interview (SI)

1) What is your favorite subject? Why?
2) Do you like science? Why?
3) What is your favorite topic in science? Why?
4) Did you like the section on force?
5) Was it a difficult or easy test?
6) Name the difficult questions?
7) Do you have any knowledge or information about force that is different from what you were taught in the science classroom?
8) Did the demonstrations and practical use of equipment help you to understand the concepts better? Why?
9) Does your science teacher make the subject fun, enjoyable or interesting?
10) Are boys or girls more encouraged to do science?
11) Is there any relevance between the stuff you do at school and your daily life activities?
12) What method (form of instruction) does your teacher use to make the concepts easier to understand.
13) What is your opinion about Vee diagramming in the lessons?
14) Do you like working in groups?
15) Do you like the atmosphere in your science classroom?
16) Any suggestions/comments you want to give?

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Appendix D

he information collected in this questionnaire is solely for the following reasons:

a) Research.
b) To find out what difficulties grade seven learners have in understanding the concept of force.

'ou are free to remain anonymous but please be as honest as possible when answering the uestions. Any additional comments are highly welcomed.

lease complete the following:

1) Gender:

Male	
Female	

2) Age:

10 years	
11 years	
12 years	
13 years	
14 years	
15 years	
16 years	
Above 16years	

2) Home Language:..

3) Name of school:..

4) Location of school:...

5) Fathers occupation:...

6) Mothers occupation:...

7) What role does your parents play in your schooling...
....

8) Do you have any difficulties in understanding the concept of force?
Yes ( ) No ( )

Explain...
....

9) To what extend do you understand the concept of force?
Average ( ) Satisfactory ( ) Poorly ( )

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10) What type of student-teacher relationship exist in your classroom?...
....

11) What method or approach does your teacher use to make the concept of force clear in class
....
....

12) Does your teacher give you the opportunity to ask questions?...........................

13) How frequently do you ask questions?
Never ( )   Sometimes ( )   Always ( )

Did you notice any difference between the lesson series on force and the ordinary lesson presented by your teacher?...
....

14) Was their anything in particular in the lesson series on force that you liked or disliked?

Likes (if any)...
....
Dislikes (if any)..
....

15) Please answer the following questions with Yes, No or No Opinion:

a) By speaking English and my home language I was able to understand the concept of Force better...............................

b) I liked the group discussion and reporting strategy...

c) I did not like the group discussion and reporting strategy................................

d) I had several opportunities to express my own opinion during the discussion and Reporting...

e) I am too shy so I did not like to work in groups...

f) Vee diagramming make me understand the topic easier................................

g) Vee diagramming is very confusing...

h) Vee diagramming make me forget information easily..............................

i) Give any additional information of the lesson on force...
....
....

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APPENDIX E

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Grade 7 **Natural Science** **August 2003**

Introducing Vee Diagramming

Most people have different ideas and opinions of what a scientist do. Some view scientists as book writers, other picture them in laboratories, or in nature studying plants and animals, in space, etc. Although they have different views, all of them are right, because science is an embodiment of all these views and more. What is your view about this?

The aim of this exercise is to find out what you think a scientist do. Work in groups of 5, and discuss in each group the questions that follow before attempting to answer.

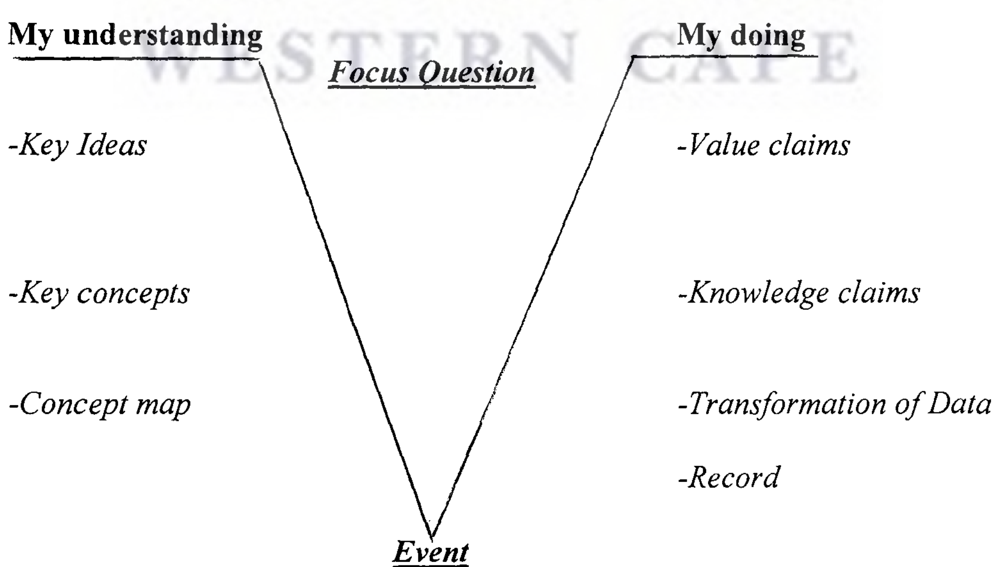
1) What does a scientist do?..
....

2) Where does a scientist work? Name at least 8 different places?........................
....

3). Explain in your own words what a scientist do in his workplace?......................
....
....

4) Why is it important for a scientist to make new discoveries?............................
....

The figure below is called a **Vee diagram**. It gives us a mental picture of what a scientist does and how he/she work. Part of his/her work is ***theory based*** (***content knowledge and information***) entitled "**My understanding**" and the other part consists of ***investigations*** (***experiments and demonstrations with instruments and apparatus to collect data***) entitled **"My doing"**.



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Grade 7 *Natural Science* *August 2003*

Force

Our aim is to construct a **Vee diagram on force**, but in order to construct a Vee diagram we need to have a good understanding of what force is. In your previous grades you were taught, ***force is defined as a push or pull action***. The question is, how you define force, if no movement is observed when a force acts on objects? Can you still call it pushing or pulling? Let us investigate this to get some clarity on force.

What is force?
Force has both magnitude and direction. It is defined as the product of mass and acceleration (F = ma), and is measured in Newton (N). Pushing, pulling, kicking, etc. are examples, consequences or visual effects of when forces act on different objects.

Mass
Every object (living or non living) on earth have mass. Mass is the materialistic composition of substances and all objects is categorized in the following way:
Light objects – small mass
Heavy objects- big mass.

If the object have a small mass than the force required to push or pull it must be small
If the object have a big mass than the force required to push or pull it must be big.
This implies the bigger the mass the bigger the force and the smaller the mass the smaller the force.

If you know the mass of any object than you can calculate the magnitude of the force, required to move the object.

Example:
Your friend has a mass of 25 kg, what is the magnitude of the force required to pick him up?

Force = mass x acceleration
= 25 kg x 10 m.s
= 250 N

The 250 N is the size op the force with which the earth pulls him downwards, therefore a force greater than 250 N is required to lift him of the ground.

Your acceleration on earth is the same everywhere (10 m.s). You will more about this later.

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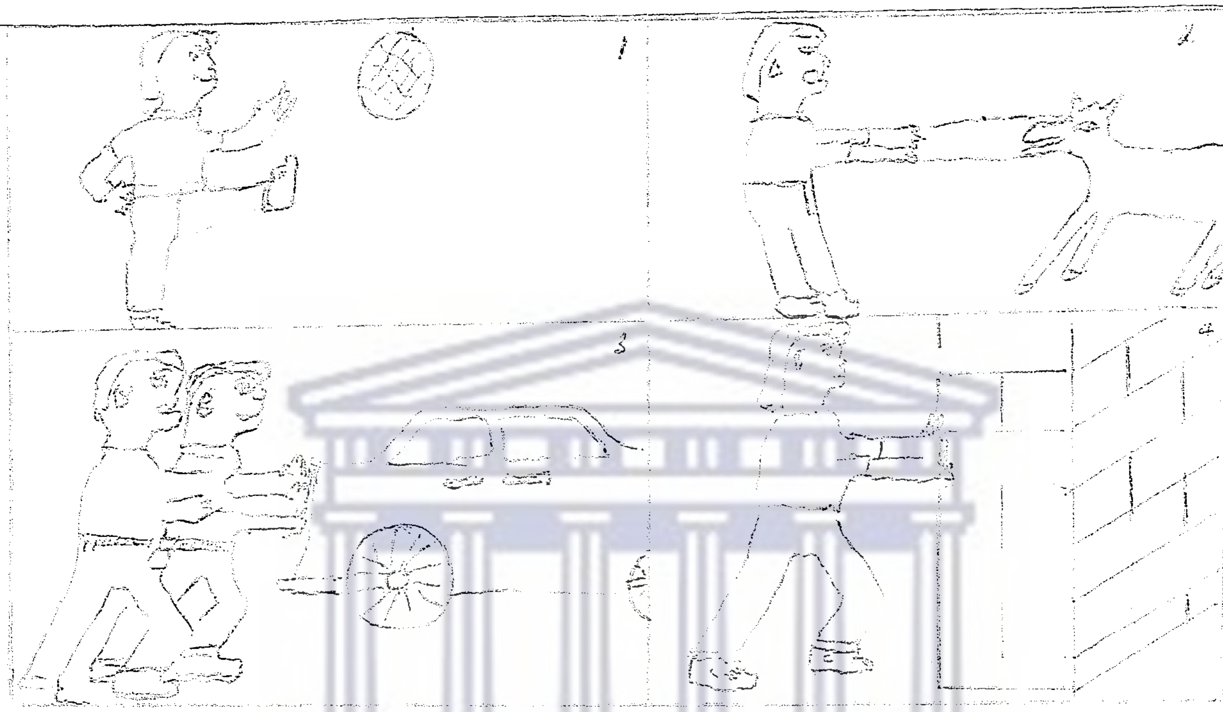
Exercise

1 Look at the pictures below and explain in your own words what you see in every picture. Identify all the forces present in each picture.



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Picture 1:...
....
....

Picture 2:...
....
....

Picture 3:...
....
....

Picture 4:...
....
....

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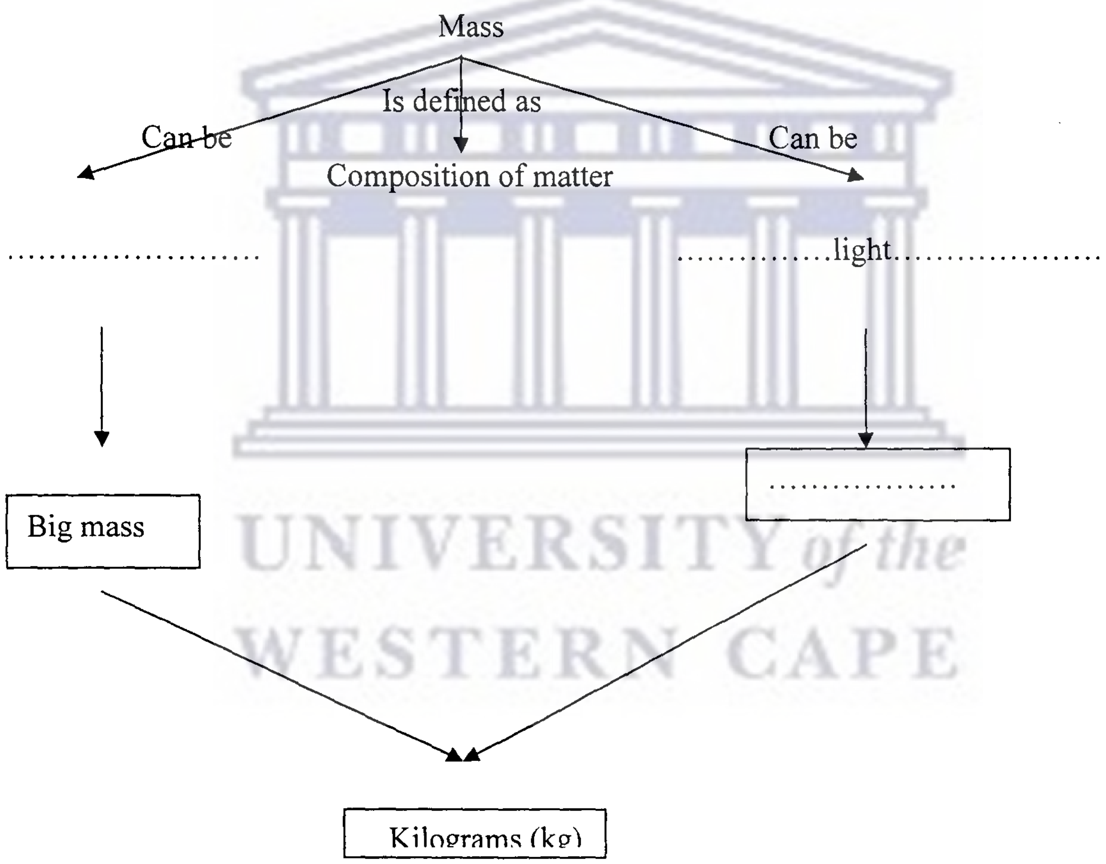
Concept Map

The following exercise must be completed in groups of 5 learners/group.

Write down all the key ideas about mass in space provided……………………………..
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………

Highlight or identify all the key concepts in the answer provided above………………
…………………………………………………………………………………………
…………………………………………………………………………………………

Complete the diagram below



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Worksheet 3: *Weight*

Every object on the earth is pulled down by a gravitational force. The gravitational force on the earth is 10 m.s., and on the moon it is approximately 1.66 m.s. The bigger the gravitational force the bigger our weight and the smaller the gravity the smaller the weight, which is the force with which the earth pulls objects downwards. Weight is measured in Newton.

On the moon people swift a result of the small gravitational force.
On the earth people walk because of a bigger gravitational force.

Weight is the product of mass and gravity (w = mass x gravity)
Mass is the measurement taken on a scale.
Gravity on the earth is 10 m.s. and 1.66 m.s. on the moon.

Example.

Calculate the weight of a man on the moon and on the earth if he has a mass of 65 kg

On the moon

W = mass x gravity
= 65 kg x 1.66 m.s
= 107 N

On the earth

W = mass x gravity
= 65 kg x 10 m.s
= 650 N

The bigger the mass the bigger the weight, the bigger the force required to move the object.

The smaller the mass the smaller the weight, the smaller the force required to move the object.

I think now you have an idea why it is easier to move a chair than a table.

Exercise

Write down the key ideas of the issues discussed above about weight……………..
…………………………………………………………………………………………...
…………………………………………………………………………………………...
…………………………………………………………………………………………
…………………………………………………………………………………………

Write down the key concepts…………………………………………………………
…………………………………………………………………………………………..

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The "My doing" part of Vee diagramming

"My doing" is found on the right side of the Vee diagram and is only concerned with the practical nature of science. It gives **you** *ideas on various methods and procedures* you *need to follow to investigate any issue in question. It includes the actual experiment that* you *design, the outcome or results generated from the experiment and knowledge and values claims that* **you** *conclude from the results* **you** *obtained.*

Measuring the magnitude of force.

Let us investigate to see if we can measure the magnitude of a force required to push or pull the following objects: ***duster, brick and your school bag***. The magnitude of the force can be determined by using a spring balance. A spring balance is an apparatus that measures the magnitude of a force required to move an object. It gives you a reading instantly and is measured in Newton.

Investigation

Each group is provided with a spring balance, and the different objects mentioned above.

Firstly, measure the mass of every object by using the scale, and record it in the table below.

Secondly, use the spring balance and write down the reading on the instrument given as soon as the object start to move

Table of results:

Objects	Mass (kg)	Force (N)
Duster		
Brick		
School bag		

Answer the following questions

1) Which object gave the smallest reading on the spring balance?................................

2) Which object gave the biggest reading on the spring balance?.................................

3) How did the mass of the objects influence the reading on the spring balance ?........

....

....

4) What can you conclude form the results..

....

....

5) What did you learn from the exercise?...

....

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Constructing the "My understanding" part of a Vee diagram on Force

Exercise:

The diagram below is a blank template of the "My understanding" part of a Vee diagram. Completed the "My understanding" part by filling in, everything about force in the spaces provided in the diagram below. This exercise must be completed in your group.

My Undersdtanding…………………………

Key ideas

………………………………………………………………………

………………………………………………………………………

………………………………………………………………………

………………………………………………………………………

………………………………………………………………………

………………………………………………………………………

………………………………………………………………………

Key Concepts:

………………………………………………………………………

………………………………………………………………………

………………………………………………………………………

Concept Map

Force

Has → *Magnitude and ………………….*

defined as → *product of mass and …………………… (F=ma)*

examples → *Pushing, …………., ………………., ………….*

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"My doing" part of a Vee diagram on force

This part only focuses on the practical aspect of the Vee diagram. It is the actual investigation, the doing of the experiment, results and the conclusions drawn from the results.

My Doing

Focus Question : It is the question under investigation, or the question you want to Answer, but with the data gathered from doing the experiment.

Eg. : What will happen if I drop two objects of different sizes and mass simultaneously at the same height.

Is the magnitude of the force the same, if I want to move a car and a desk.

Why does my arm get tired if I hold a book for 10 minutes with an outstretched.

It is the procedure, protocol or method you follow to investigate focus question. It is also referred to as the problem task.

Take two objects and measure the mass of each object. Drop it Simultaneously at the same heights and observe what happens.

Use a spring balance and measure the force required to push/pull A cup and a chair and record the results.

Event

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Exercise

1) *Write down a focus question on force that you and your group would like to Investigate.*

……………………………………………………………………………………….

………………………………………………………………………………………

………………………………………………………………………………………

……………………………………………………………………………………….

2) *Construct a methodology or procedure that your group will follow to investigate the focus question.*

……………………………………………………………………………………………

…………………………………………………………………………………………..

…………………………………………………………………………………………..

…………………………………………………………………………………………..

…………………………………………………………………………………………..

…………………………………………………………………………………………..

…………………………………………………………………………………………..

3) *What will be the outcome of your results? Explain the outcomes*

……………………………………………………………………………………………….

……………………………………………………………………………………………….

……………………………………………………………………………………………….

……………………………………………………………………………………………….

……………………………………………………………………………………………….

………………………………………………………………………………………………..

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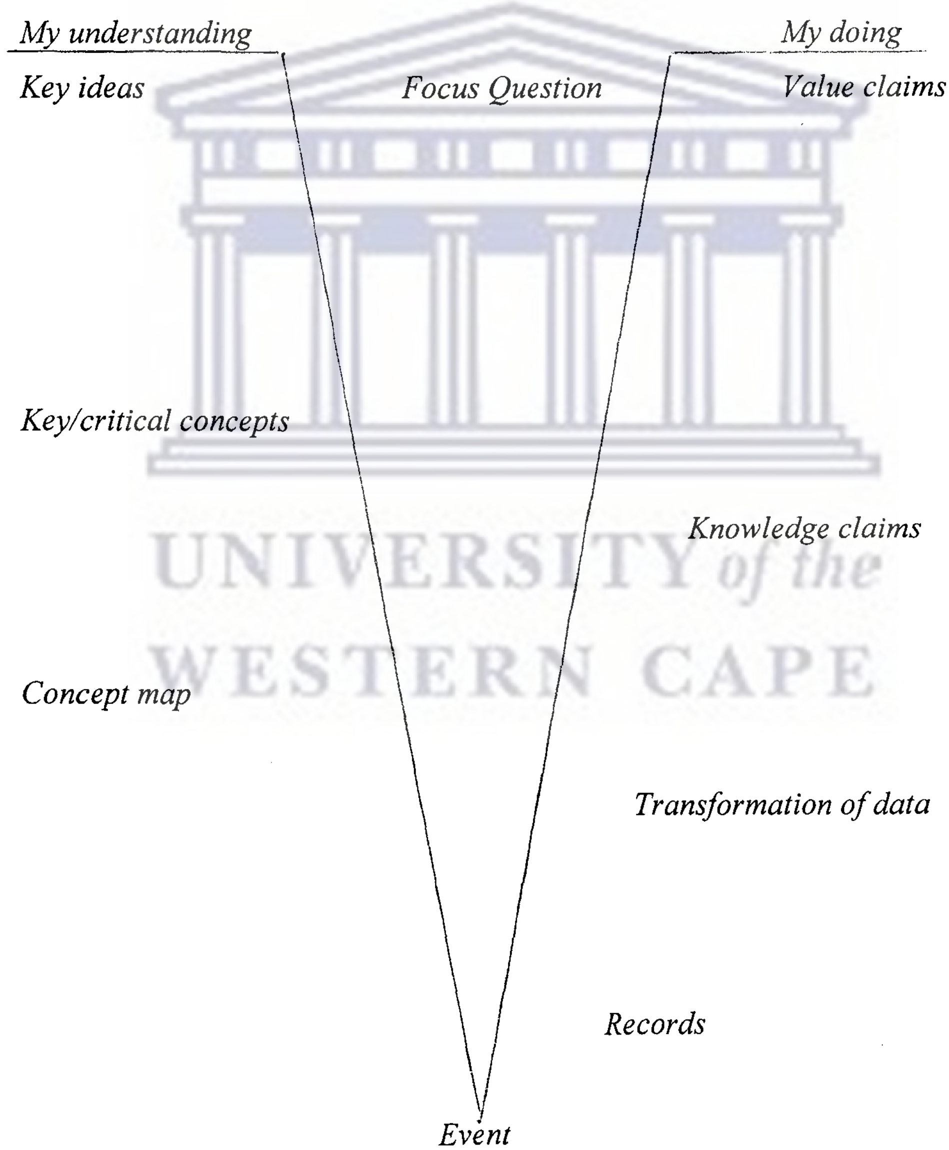
Grade 7 ***Natural Science*** ***August 2003***

Vee diagram on force

Work in groups of 5 learners/ group and construct a concept map on force. Both parts of the Vee diagram need to be completed the "My understanding" and the "My doing" part. You can decide in your group what focus question you would like to investigate.

Vee diagam on force



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APPENDIX F

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Appendix F

Grade 7 | **Natural Science** | **August 2003**

Force

Course Outline:

1. **Force**

   Discussing your own ideas about force.

   Defining force.

   Examples of force

   Demonstrations of force

2. **Mass**

   Defining mass.

   Heavy objects.

   Light objects.

   How mass relate to force.

   Measurement of mass

3. **Weight**

   Defining weight

   Relationship between weight and force

   Calculating weight.

4. **Gravity.**

   Defining gravity

   Identifying gravitational force.

   The difference between the gravity on the earth and on the moon.

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