

**INCORPORATING TECHNOLOGY INTO THE LESOTHO SCIENCE
CURRICULUM: INVESTIGATING THE GAP BETWEEN THE
INTENDED AND THE IMPLEMENTED CURRICULUM**

Litšabako Ntoi



UNIVERSITY of the

**A Thesis submitted in Partial fulfilment for the degree of Doctor of Philosophiae in the
Department of Education, University of Western Cape.**

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Key words

Technology

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Implemented curriculum

Curriculum development

Lesotho

Science, technology and society

Technology as application



Abstract

The inclusion of technology in the school curriculum has been a concern in many countries following the 1990 Jomtien World Conference on Education for ALL (Jenkins, 1996). However, there are different perspectives and views about technology education. As a result technology has been included in the school curriculum in varied ways.

In recognition of the importance of technology in economic development, Lesotho has attempted to include technology in the school curriculum by incorporating science and technology. This study evaluated the Lesotho science curriculum which incorporates technology.

The evaluation study is based on the framework first proposed by Stake (1967). Stake's model addresses the relationship between the intended curriculum and the implemented curriculum (Stenhouse, 1988). In this study the intended curriculum is defined as the curriculum plan as depicted in the curriculum materials such as the syllabus, the examinations questions papers and the textbook which was used as an exemplary material for teaching the science-technology curriculum. The implemented curriculum is viewed as what actually happened at school level as teachers tried to interpret the curriculum developer's plan. Although Stake's model served as a guide in the collection and analysis of empirical data, other theoretical areas supported it. These included Gardner's (1990) approaches to the incorporation of science and technology; the constant comparative approach (Merriam, 1998); and some aspects of curriculum theory, particularly curriculum development and curriculum evaluation as espoused in the works of certain scholars (e.g. Ornstein and Hunkins, 2004; Stenhouse, 1988).

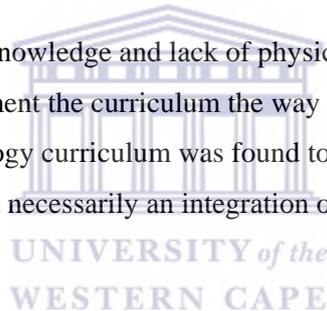
The study was designed as a multiple-site case study (Merriam, 1998). The sites where in-depth study of the implemented curriculum was done were four high schools in Lesotho. The intended curriculum was mainly examined by analysing the curriculum materials such as the syllabus, the examinations question paper and the textbook. The methods that were used for collecting the data were interviews, classroom observations, document analysis, and the achievement tests.

The results of the study indicate that the Lesotho science-technology curriculum strives towards the attainment of scientific and technological literacy. The approach to science and technology education that was envisaged was the science, technology and society approach (STS). However, the findings of the study suggest that the technocratic perspective to curriculum development and consequently the curriculum design model adopted by the curriculum developers, teachers' perceptions of the science-technology curriculum, learners' background knowledge and lack of physical facilities might have contributed to lack of success in the attainment of the goals of the Lesotho science-technology curriculum.

In relation to the planned curriculum, the findings of the study show that the Lesotho science-technology syllabus has separated the sciences into biology, physics and chemistry and this contradicts the planned integration. In addition, the scope and sequence of this syllabus follows the spiral approach and it is based mostly on science content. Hence, the inclusion of technology is superficial. Furthermore, the vertical design adopted in developing the science technology curriculum does not seem to fit well with an STS approach. Hence, there is a mismatch between the syllabus objectives and the learning outcomes.

The results of the study further indicate that there were no teacher training efforts geared towards the implementation of the Lesotho science-technology curriculum implementation. As a result teachers in the study formulated their own perception of science integrated with technology. Teachers perceived technology as the application of science. In their teaching they often used technology-as-an-illustration approach. In addition, they relied on learning outcomes for determining the competencies that learners needed to acquire by experiencing the science-technology curriculum. But the learning outcomes did not indicate the scope of treatment of different technological applications and artefacts. Consequently, they treated the technological applications at different levels of cognitive demand.

Furthermore, learners' background knowledge and lack of physical facilities were found to be a hindrance as teachers tried to implement the curriculum the way they perceived it. Consequently, on implementation, the science-technology curriculum was found to be essentially a science curriculum rich in technological applications not necessarily an integration of science and technology in one curriculum.



Declaration

I declare that *Incorporating Technology into Lesotho Science curriculum: Investigating the gap between the intended and the implemented curriculum* is my own work, that it has not been submitted before for any degree or examination in any other university, and that all the sources I have used or quoted have been indicated and acknowledged as complete references.

Full Name

Date.....

Signed.....



Dedication

To my late husband-*Thobei Ntoi*



UNIVERSITY *of the*
WESTERN CAPE

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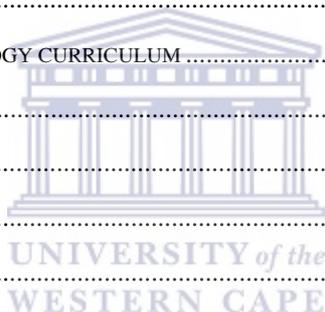
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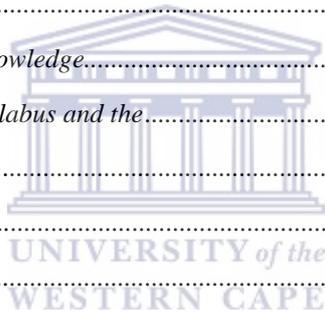
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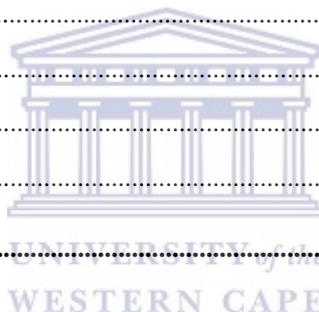


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1. Introduction

1.1 Background

Lesotho is a small landlocked country, found south of the Sahara, with an area of 30335 square kilometres. It is found between latitudes 28 and 31 degrees south and longitudes 27 and 30 degrees east. It is completely surrounded by the Republic of South Africa and is largely a mountainous country. All of its territory lies above an altitude of 1000 metres. Its population is about 2.2 million (Ministry of Trade and Industry, Cooperative and Marketing, 2004).

Lesotho has limited agricultural potential. The main source of income for Lesotho is the export of garments from manufacturing industries and royalties to the Lesotho Highlands Water Project, which exports water to the Republic of South Africa. Lesotho is regarded as one of the poorest countries in the world and is ranked number 127 of 174 countries on the UNDP's Human Development Index. The economy of Lesotho began to decline significantly as a result of political unrest in 1998. Among other factors, which contributed to the decline, were drought, retrenchment of Lesotho mineworkers from the mines in South Africa, and poor performance of state owned utility companies (Ministry of Education, 2004).

As one of the strategies for supporting the economy, the government of Lesotho aims to have enough skilled, innovative and technically trained manpower and a competitive science and technology infrastructure (Ministry of Natural Resources, 2002). In its efforts to attain this goal, it established the Department of Science and Technology in 1996. Some of the aims of this department are to:

Raise awareness on the role of science and technology in socio-economic development.

Promote and support indigenous technology, in order to increase and strengthen the theoretical base and practical knowledge base of the nation (Ministry of Trade and Industry, Cooperative and Marketing, 2004:44).

In pursuance of its goals the Department of Science and Technology has embarked on awareness campaigns in the form of workshops and exhibitions in the country. At school level these exhibitions are in the form of "Mathematics and Science Fairs" which are held annually at regional and national level through the initiative of the mathematics and science

teachers. The department further supports the dissemination of locally initiated technologies such as biogas and solar technologies (Ministry of Trade and Industry, Cooperative and Marketing, 2004).

Furthermore, the government of Lesotho envisages the provision of basic education to all Basotho as central to enhancing social and economic development. However, the educational system still experiences great pressure in expanding education. Many children from disadvantaged families do not have access to ten years of basic education. The curriculum is overloaded with many academic subjects and learners develop minimum practical skills during their schooling years. As a result of superseded assessment practices which include high stake examinations that take place at the end of primary, junior and senior secondary education, there are high repeat and dropout rates. Many schools are still owned by churches although the government of Lesotho pays teachers' salaries. There are generally inadequate facilities in the schools. Nevertheless, the Ministry of Education is aware of this status and is trying to put policies in place which can address the situation (Ministry of Education and Training, 2004).

Consequently, the Lesotho Ministry of Education vision for 2005-2015 is “to achieve scientifically, technically and technologically well-educated and functionally literate Basotho by the year 2020” (Ministry of Education, 2004: 2). According to Lewin (1992:1):

Human resource development has become a central feature of most national development strategies and within this the emphasis has more often than not been on the acquisition of scientific and technological skills and capabilities.

According to Ogunniyi (1996), the link between science and technology and economic growth is a complex one. However he indicated that there is evidence showing that there is a strong link between science and technology with economic progress.

The inclusion of technology in the school curriculum in Lesotho is seen as a strategy for achieving scientific and technological literacy for all the citizens. However, trends in the science education curriculum show that the issue of scientific literacy and “Science for All” is the current trend in science education, following the Jomtien World conference on Education for All (Jenkins, 1996; Yoloye 1998). According to Jenkins (1996), scientific literacy is seen as way of disseminating to the general public the understandings associated with science and technology. Through these understandings scientists and technologists sought to benefit political support for their work. Nevertheless the argument for scientific literacy is commonly associated with economic prosperity, raising the quality of decision making and

enriching the life of individuals. Despite the view people have of technological literacy, the inclusion of technology education into the school curriculum like many other curriculum issues, is faced with many competing influences. Therefore there are diverse and varied arguments for its inclusion. In addition Donnelly (1993) and Bungum (2005) indicated that the competencies that need to be promoted by technology education are not explicit. This makes it different from other school subjects which are well established in the curriculum. As a result, transformations in technology education have taken various forms in different countries.

Generally technology is included in the school curriculum as a stand-alone subject or it is integrated into other subjects. The literature on the incorporation of science and technology shows that in many countries, the incorporation of technology into science has been mostly in the form of projects which were optional or added on to the science curriculum. Examples are PLON material developed in the Netherlands, ALCHEM developed in the 1970s in Canada, and The Social Consequence of Science and Technology (IST) which are curriculum materials developed in the USA (Fensham, 1988; Layton, 1993). In other countries, such as Botswana and the Philippines, science is integrated with technology and has replaced the science curriculum at junior secondary level (Nganunu, 1988; Tan 1988).

This suggests that including technology in the school curriculum brings the issue of scientific and technological literacy into the arena of technology education curriculum making and the educational context of the curriculum. According to Cornbleth (1990) curriculum development relates to the social, political, economic and demographic conditions which have the potential to determine the constraints, the demands and priorities that can influence the curriculum.

According to Sebatane (2000), in the case of Lesotho, the formal education system takes sixteen years. The primary cycle takes seven years, at the end of which learners sit the Primary School Leaving Examination (PSLE). Secondary education takes five years, three of which are for junior secondary education and two for senior secondary education. The three years of junior secondary education lead to the Junior Certificate (JC/grade 9).

O'Level/grade12 examinations are taken at the end of two years of senior secondary. Tertiary education ranges from a three year diploma in technical schools to a four-year degree at the University level. Figure 1 shows the primary, junior secondary and senior secondary structure of the educational system in Lesotho.

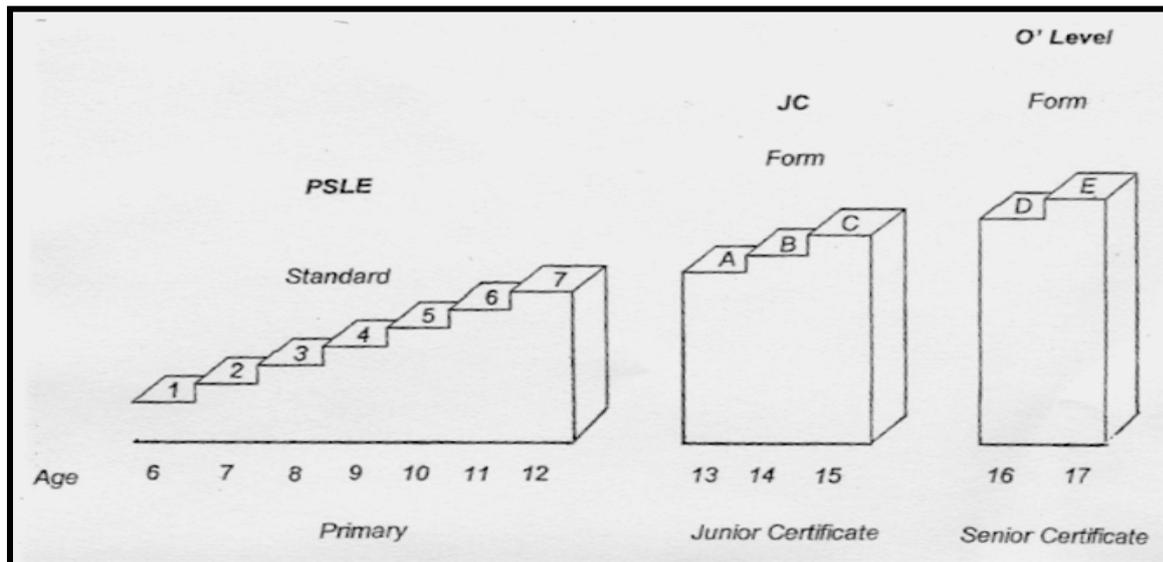


Figure 1 The structure of the Lesotho school system

In Lesotho, the task of developing curriculum policy, approving syllabi, checking curriculum materials, and approving the curriculum program and monitoring progress is entrusted to the National Curriculum Committee (NCC). The NCC is composed of the Principal Secretary of Education, the Director of National Curriculum Centre (NCDC), the Directors of the National University of Lesotho (NUL) and Lesotho College of Education (LCE) and other directors of departments of education. The NCC committee members also include the senior education officers for primary and secondary, proprietors of schools and a member of the public and teachers' organization representatives. Currently the Registrar of the Examinations Council of Lesotho (ECoL) is also a member of the NCC (Ministry of Education, 1980). As constituted the NCC is made up of policy makers. As such the task of checking curriculum materials can be assumed to be superficial since most of the members do not necessarily need to have expertise in either curriculum development or subject content

The National Curriculum Development Centre (NCDC) develops the Primary and Junior Secondary curriculum using the system of subject panels. The Panels also develop curriculum materials such as textbooks, teachers' guides and other teaching aids. According to the Ministry of Education (1980:10) the panels are supposed to: "develop required new syllabi inclusive of the specific objectives, content elements, suggested instructional strategies, materials, and books as well as evaluation." The development of the syllabi is based on the policy guidelines, which have been established by the NCC. Each subject in the school curriculum has its own panel. The Ministry of Education (1980) indicates that the

panel should consist of a curriculum specialist, and teacher educators, practicing teachers, examinations subject officers and subject inspectors. The curriculum specialist is taken to be the curriculum expert who guides the panel through the curriculum development process. Currently NCDC develops curriculum for junior secondary and primary education. The senior secondary syllabi are still prepared at the University of Cambridge. The system of subject panels allows stakeholders in curriculum to take part in curriculum development. Although the NCDC develops the curriculum, it is not responsible for national examinations.

The Examinations Council of Lesotho (ECoL) is in charge of public examinations. Public examinations in Lesotho take place at the end of Primary School, Junior Secondary and Senior Secondary School. Currently, the ECoL takes full responsibility for Primary and Junior Secondary Examinations. The examinations are supposed to be aligned with the syllabi, which have been developed by the different subject Panels. However, O'Level Examinations, which are taken at the end of the senior secondary education, are still set in the UK though administered in Lesotho by the ECoL (Ministry of Education, 1988).

Experience has shown that in many African countries, curriculum practices have, in one way or the other, been influenced by international trends. Science education developments in the West have influenced developments and growth of science education in Africa. However, the development of science education curricula remains an issue of pertinent concern in many African countries.

Lesotho has been following the Cambridge Overseas Schools' Certificate syllabus since 1961. During the 1980s Britain moved from O'Level to General Certificate of Education (GCSE) (Dekker & Schalkwyk, 1989). The 1980s curriculum and assessment reforms in the UK were considerable and countries which were following O'Level such as Botswana, Lesotho and Swaziland had to reconsider their curriculum and assessment systems. As a result, Lesotho began to initiate localization of the O'Level curriculum and assessment systems.

Lesotho began localizing matters relating to examinations in 1989. A national review of all secondary curricula began later in 1994. During this review the science panel was charged with the responsibility of reviewing the science curriculum.

Upon localizing the science curriculum, the science panel aimed at closing the gap in content and skills that was observed between the JC and O'Level. The panel further tried to place the science content in the context of Lesotho. The panel attempted to incorporate issues of technology, environment, population and family life into the science syllabus. Furthermore

the panel aimed at improving the methods of teaching science. The reviewed curriculum for junior secondary was first put on trial in eighteen schools in the country in 1998. Although there was no report on the trial of the curriculum, the reviewed science curriculum was introduced to all schools in January 2002.

Rationale for the study

Globally technology is taken to be an important component of the school curriculum. Much effort has gone into developing curricula and curriculum materials for science and technology. However, the objectives and content of technology as a school subject are not clearly defined (Lewis, 1991; Hansen & Froelick, 1994; Sjoberg, 1995). Specifically, there is very little empirical research on the relationship between science and technology as an issue relating to curriculum content (De Vries, 2006). This study presents the empirical work on the evaluation of the Lesotho junior science curriculum which has incorporated technology. It is an attempt to examine the science-technology curriculum content as planned and how teachers modify it as they interpret the developers' plans at school level.

The aim of this study is to evaluate the Lesotho junior secondary science-technology curriculum (LJSTC). More specifically, the aim is to assess the nature of the LJSTC and the nature of implementation in terms of teacher, learner and learning environment. In specific terms the study aims to investigate the nature of the planned and the implemented LJSTC. The planned curriculum is taken to be the official curriculum that was documented and the implemented curriculum refers to the curriculum that was actually experienced by learners as teachers tried to interpret and implement the intentions of the curriculum developers (Graham-Jolly, 2002). This study will provide stakeholders in science and technology education with information that can help them deal with challenges associated with the content of the science-technology curriculum and its implementation. This information is important to curriculum developers, policy makers, teachers, teacher educators, and other interested parties both in Lesotho and other countries.

1.2 Research questions

The study is guided by the following questions:

1. What is the nature of the new Lesotho junior science-technology curriculum?

2. How is the new science-technology curriculum implemented in the classroom?

(a) What is the nature of *teacher training* relative to the implementation of the science-technology curriculum emphasis?

(b) What are science *teachers' perceptions* of science-technology inclusion?

(c) What is the nature of the teacher-learner-material *interaction*?

(d) What are the *outcomes* of the science-technology curriculum?

There are various views and assumptions underlying the incorporation of science and technology. *Question one* investigated specifically how the incorporation of technology content and science content proceeded in the Lesotho junior science curriculum. The purpose of this question was to find out what the intended science-technology curriculum was in the context of Lesotho.

Question two focuses on how the Lesotho science-technology curriculum was implemented in the classroom. Firstly, this question aimed to establish how teachers were trained in preparation for implementing the science-technology curriculum. Secondly, it examined teachers' perception of the inclusion of technology in the science curriculum. It further investigated how teachers translated the planned curriculum under the circumstances which prevailed at school level in Lesotho. Furthermore, the study tried to establish the consequences of implementing the science-technology curriculum in the way teachers did this under the circumstances that prevailed at school level.

1.3 Arrangement of the thesis

This thesis is divided into six chapters. *Chapter one* is the introduction chapter. It presents the background and the problem of the study. This chapter also deals with the research questions. It further describes how chapters are arranged in the thesis.

Chapter two deals with the literature review. It presents the literature on developments and trends in the science education curriculum. It further discusses the literature associated with technology and technology education. It highlights the understandings and perspectives linked with technology education and ways in which science is integrated with technology. The inclusion of technology education in the school curriculum can be viewed from the perspectives of curriculum theory and practice. Therefore the literature on curriculum design and development as well as curriculum evaluation has also been included in the chapter.

Chapter three outlines the theoretical framework of the study. The chapter begins by highlighting curriculum theory. It particularly focuses on curriculum development, design and evaluation. Stake's (1967) congruency-contingency model as an approach to curriculum evaluation is discussed in this chapter. Stake's model is the main theoretical framework of the study. The chapter further presents the constant comparative approach (Merriam, 1998) which is used in analysing qualitative data. It also deals with other theoretical areas which have been used in the analysis of data relating to science and technology curriculum such as Gardner's (1990) approaches to the incorporation of science and technology.

Chapter four describes the methodology adopted in the study as well as the methods used in collecting and analysing data. It includes the description of the research design, the setting, procedures for selecting the research setting and informants, the measuring instruments, and procedures for collecting and analysing data. The chapter also includes information that was found relevant in the conduct of this study such as the pilot procedure, issues of reliability and validity as well as ethical considerations.

Chapter five presents results and interpretations on the analysis of data. This chapter is divided into two sections. Section one presents the findings regarding the intentions of the LJSTC. These are the findings related to the planned curriculum as depicted by the curriculum materials. These materials are the junior science syllabus, the textbook, and the Lesotho Junior Examinations question papers for science. The section further describes the intended curriculum as perceived by the curriculum developers. Section two presents the findings and interpretations on the implemented science-technology curriculum as established through classroom observations and interviews.

Chapter six is the concluding chapter of the thesis. This chapter responds to the research questions by bringing together the findings and interpretations that were made in chapter four. It further makes suggestions and recommendations on the results obtained from the study. It also highlights the limitations of the study. It ends with the concluding remarks and shows the questions, which have not been answered by the study.

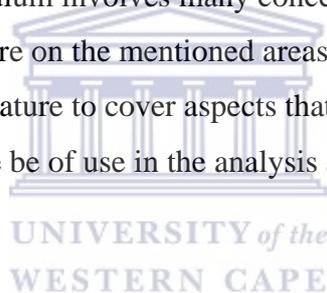
2. Literature review

2.1 Introduction

This chapter surveys the literature on developments and trends in science education curriculum. The chapter further discusses the literature associated with technology and technology education. It further puts forward the understandings and views held by different stakeholders in technology education. Ways in which science is integrated with technology are also discussed in this chapter.

In this study the inclusion of technology education in the school curriculum has been viewed from the curriculum theory and practice perspectives. For that reason, the literature on curriculum design, development and evaluation has also been included in the chapter.

Technology education and curriculum involves many concepts. As a result the chapter has not attempted to cover the literature on the mentioned areas entirely. However an attempt has been made in the selection of literature to cover aspects that could support the theoretical framework of the study and hence be of use in the analysis and interpretation of data collected in the study.



2.2 Reforms and transformations in Science education

2.2.1 Global trends

The survey of the literature on school science and technology curriculum shows that the first wave of science curriculum reforms began in the 1950s. These reforms were addressing the dissatisfaction with the preparatory role of science in secondary education. The science curricula of the 1950s emphasised scientific understanding and scientific thinking. These curricula mainly prepared learners for further education in science. The reforms of the 1950s were led by scientists rather than educators and were found difficult by both learners and teachers. As a result they made many learners shy away from science (De Feiter, 1996).

The second wave of curriculum reform followed in the 1960s and 1970s. These waves of curriculum reform were addressing the imbalance in focus of the first curriculum reforms, which were emphasizing only the preparatory role of science in secondary education and

neglecting the other group of learners who needed science knowledge essential for life after schooling (De Feiter, 1996 & Fensham, 1997). At the same time there was growing concern for environmental issues and the interaction of science and society. Consequently, science courses of this time had to respond to these concerns. Courses like Environmental Education and Science, Technology and Society (STS) emerged. These reforms came to be known as 'Scientific and technological literacy for all'. The period around the 1980s was not a period of large-scale curriculum innovation but rather a period of reflections on the development in science education achieved that far. However the products of this period focused more on the development of science curriculum in junior secondary education and non-science streams in senior secondary education. Collectively these reforms were seen as the third wave of curriculum reform. They also targeted the issue of science for all (De Feiter, 1996). Although much effort has gone into developments in science and technology curriculum Sjoberg (2003) indicated that the number of students who opted for science courses at both school level and tertiary institutions in developed countries has decreased.

In general terms some of the recent trends in science education are characterised by the following: (1) Early specialisation is discouraged and less emphasis is placed on separate academic science subjects. (2) Generally more subject integration is encouraged and subjects tend to be separated at senior secondary. (3) The science and technology curriculum has widened to include cultural, historical and philosophical aspects. (4) The science and technology curriculum tends to include other science and technology curriculum emphasis such as the nature of science; environmental education; technology; science, technology and society (STS); information technology as a subject and as a tool and attention to ethics. (5) In addition the science and technology curriculum regards context that has meaning and relevance to the student as important for teaching and learning (Sjoberg, 2003).

In brief the general global picture regarding current goals for science and technology curriculum show that the goal for science education has shifted from preparing learners for further learning to addressing the issue of science for all.

2.2.2 Developments in Africa

As indicated Chapter 1, transformations in science education in the West have had influence on developments and growth of science education programmes all over Africa; however, science education curriculum developments have always been a concern in African countries.

Before the early 1960s science education syllabi in many African countries consisted of topics in different subjects geared towards the fulfilment of overseas examinations. In most cases the science education programmes were academic, descriptive and knowledge-based (Ogunniyi, 1986; Lewin, 1992; Yoloje, 1998).

In the early 1960s rapid expansion of school enrolments became the characteristic of many developing countries. This expansion was due to planned expansion of human resource and the social demand for greater access to the school system. The increase in school population coupled with unemployment led many governments to introducing science education programmes which were geared towards addressing the issue of unemployment. As a result science education programmes with vocationally relevant materials were introduced in some African countries and they adapted the rhetoric of education for self-reliance (Ogunniyi, 1986; Lewin, 1992).

Ogunniyi (1986) indicated that the concern for rural integration also intensified around the 1970s and this led to the inclusion of agricultural science and technological and sociological topics in the primary and the lower secondary science curriculum. A shift towards inquiry learning, student-centred learning, integration and placing science in context began around the same time.

It has already been indicated that trends in science and technology education in Africa are not isolated from global trends. In many countries the goals for science education in Africa have shifted over time. The current goals for science education are attempting to address the issue of Science for All. It is in addressing the issue of Science for All, that the concepts such as “relevance”, “science, technology and society” and “environmental education” have become the subjects of concern in many African countries. These issues constantly relate science to local technologies, industry and environment (Putsoa, 1999). In pursuance of the goals mentioned some African countries have developed science and technology courses which incorporate science and technology. An example is Botswana and Nigeria. According to Nganunu (1988), Botswana introduced the STS course in secondary education in 1986. Jegede (1988) indicated that Nigeria introduced the STS courses at Ahmadu Bello University and Ibadan University with the aim of later introducing this course in secondary education.

Despite evidence to show that there is no direct relationship between vocational education and economic growth, most African countries still offer traditional pre-vocational and vocational subjects such as woodwork, metalwork, home economics and the like. The

argument for vocational training in enhancing economic growth has been very influential (Kerre, 1994). In developing countries vocational training is also promoted mainly because it reduces pressure on expensive higher education (Layton, 1993).

Lewin (1992) indicated that in many cases the issues of science for all and scientific literacy is associated with science and technology and economic development. The science for all movement calls for a broad and balanced science curriculum. The broad and balanced curriculum has several elements among which are the inclusion of science and society, incorporation of environmental issues and the introduction of technology in the school curriculum.

Some of the trends that Lewin (1992) reported were most likely to impinge on the developing countries, in the 1990s still hold currently as indicated in the previous section. Lewin indicated that:

The tendency to make science available to all secondary learners will continue. This implies more integrated/combined/co-ordinated/modular approaches, which balance content from the traditional disciplines.

Teaching scientific skills and cognitive processes related to scientific problem solving will remain the curriculum development orthodoxy.

Technology will form a new focus of interest in curriculum development complementing or even leading new science curricula with an emphasis on the skills needed to solve real life problems.

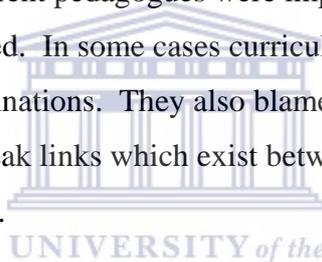
Broader definitions of science education that absorb health education, nutrition, earth science, etc. will become more acceptable as will links with other curriculum areas. Science and society and environmental issues will appear more frequently in new curricula as their importance for the prevention of global equilibria becomes more apparent. These initiatives may be linked to attempts to reduce stereotyping of science (as 'masculine', 'foreign', 'and difficult') with a view to improving participation of disadvantaged groups (Lewin, 1992:21).

According to Yoloye (1998), despite efforts that have gone into science education curriculum reform, the quality of science education in most African countries has declined and the gap between the developed world and Africa as far as science education developments are concerned has widened. Many reasons are put forward for this state of affairs. According to Lewin (1992), economic deterioration in developing countries, has led to lack of educational resources, especially in countries which are experiencing structural adjustment programmes, African countries included. Economic deterioration coupled with high population growth rates, which has resulted in high school enrolments, has put a burden on national income. As a result educational expenditure per child has declined to a level not comparable with that in richer countries. The other reason he put forward is the migration of qualified personnel

including teachers to other countries where there are better opportunities. Ogunniyi (1986) in his review on Science Education developments in Africa identified constraints such as:

- the rapid increase in student population owing to the implementation of universal primary and secondary education in several countries;
- the shortage of funds and consequently of laboratory facilities - a situation caused by the current world wide recession;
- the shortage of well-trained science teachers and laboratory assistants;
- rapid rate in which teachers are transferred;
- the negative influence of external examinations;
- the rapidly changing socio-political conditions and attendant contradictory educational policies, and many more (p.113).

Lewin & Dunne (2000) indicated that the need for examinations to support curriculum initiatives has been voiced in many African countries. However, this has not been achieved because new programs with different pedagogues were implemented before appropriate assessment strategies were devised. In some cases curriculum development proceeded independent of appropriate examinations. They also blamed the mismatch between curriculum and assessment on weak links which exist between curriculum and assessment bodies in many African countries.



In summary many reforms in science and technology curriculum are similar in both developed and developing countries. Mainly there has been a shift in science and technology curriculum goals. Initially the science and technology curriculum emphasised the preparatory role of science. Currently the focus is on science for all. However, in the developed countries as indicated by Sjoberg (2003) the number of learners opting for science both at school and tertiary levels has decreased. In Africa the quality of science education provided to learners has declined (Yoloye, 1998).

2.3 Technology and technology education

As indicated the issue of scientific and technological literacy for all is the current trend in science education. According to Jenkins (1996), the issue of scientific and technological literacy for all has been on national and international political agendas following the Jomtien World Conference on Education for ALL in 1990. It is not therefore surprising that there are

efforts in many countries to include science and technology or technology education in the school system. The question is what is technology?

2.3.1 What is technology?

Technology has multiple meanings and encompasses a lot of connotations. Its meaning depends on the context in which it is used. It can be used in describing a certain type of knowledge like design and building (Layton, 2006). In some cases technology refers to types of technologies, for example: food technology, material technology, space technology and so on. It can as well be used in describing artefacts like the sewing machine, the computer or the hoe (Jenkins, 1996). The meaning of technology also shifts across languages. For example, 'technology' has two meanings in French. It can mean organised knowledge and skills and is referred to as (technologie) or it can denote scientific knowledge (technique) (Gardner, 1994). As defined in the dictionary technology is the:

applied science, technical method of achieving a practical purpose, the totality of means employed to provide objects for human substance and comfort (Webster's New Collegiate Dictionary, 1998:1188).

There are many definitions of technology which often associate technology with human welfare (Ogunniyi, 1996; Layton, 2006; Webster's New Collegiate Dictionary, 1998). In general terms technology is taken to affect human life since it has influence on the economy, the politics and social relationships (Raaf & De Vries, 1987). However, Sjoberg (1995:8) argued that technology is not always aimed for human welfare. He indicated that:

The war technologies have been mentioned as examples of technologies that certainly do not aim to meet human needs. And for the modern technologies like home electronics, one may well describe this as a development where the characteristic is not to meet needs, but to create new "needs" in the market.

The different meanings attached to technology also depict the views about technology. Gilbert (1992) indicated that there are three points of views held about technology. These are: the 'human view' which sees technology as responding and serving human needs; the 'titanic view' which takes technology to be heroic and attempting to control nature; and the 'satanic view' in which technology is used to produce destructive machinery and environmental problems. Generally technology is a fluid term, and its meaning depends on the context in which it is used. Hence, Bungum (2003:5) indicated that:

The concept of technology is familiar to most people and brings about a variety of associations. Yet, formulating a precise definition of the concept or a functional description that captures the essence of these associations is not a straightforward matter.

2.3.2 Technology education

As a result of the diversity in the meanings of technology and differing views to it there is no common usage and understanding of the word “technology” (Sjoberg, 1995). It is not surprising therefore that the phrase “technology education” is also open to many interpretations. Parker and Albert (1998) indicated that most people especially those who are not involved in education associate technology education with computer education. Others relate it to information technology. Medway (1993) indicated that some of the meanings of technology found among primary teachers include: up-to-date craft work, applied science, something which has wheels, making models, problem solving, and acquainting learners with industry. Gardner (1994) reports on several studies in which it was found that secondary teachers took technology to be the application of science. In their research and development of Project “Physics and Technology” in the Netherlands, Raat & De Vries (1987) found that secondary learners associated technology with machinery.

The problem of technology education does not only emanate from its meaning, but technology education like many other curriculum issues is faced with many competing influences. Layton (1994), Gilbert (1992) and McCormick (1992) indicated that there are many stakeholders in technology education who have different opinions about the reasons behind the inclusion of technology in the school curriculum. Among the stakeholders in technology education there are: (1) the economic instrumentalists, who see technology as a contributor to economic growth. (2) The professional technologists, who argue that science, arts and technology, are areas of knowledge, which should be seen as such, and technology is comparable with the other two. (3) Sustainable developers, who argue that learners should be empowered with knowledge, skills and values that would allow them to control technological developments such that they work towards achieving quality of life not only for themselves only but also for other generations to come. (4) Girls and women, who stand to counter the gender biases that are currently observed in technological activities. Others include the defenders of democracy and liberal educators who all argue for the inclusion of science and technology from their own camps. Some of the orientations that have been described above can easily become the goals for the inclusion of technology in the school curriculum.

Due to the varied understandings and perspectives that stakeholders in technology education have, it has developed in different directions globally. According to Treagust & Rennie (1993) and Allsop & Woolnough (1990), technology education has developed along four different directions. The first direction is dominated by crafts subjects; the second focuses on high tech advances such as computer and electronics; the third presents technology as an engineering course at secondary school; and the fourth presents technology as the subset of science education. De Vries (1994) classified the directions in which technology education has developed in a similar manner but extended the list of the different ways in which technology education has developed. His list of approaches consists of: the craft oriented approach, the industrial production approach, the high tech approach, the applied science approach, the general technological approach, the design approach, the key competence approach and the science/ technology/ society approach. The *craft oriented approach* takes technology education as an introduction to vocational training. It focuses on practical making abilities using ready made designs and materials (mainly wood and metal). The *industrial production approach* is similar to the craft oriented approach in that it encourages production of working pieces but goes further to make learners learn how products are made in industry. The *high-tech approach* encourages learners to use high-tech equipment such as computers. It is also production oriented. The *applied science approach* was developed by science educators in their efforts to make science relevant. The elements of design and creativity do not feature in this approach. De Vries (1994:46) indicated that:

According to this approach the relationship between scientific knowledge and technological product is very straightforward. The pupils are motivated to investigate scientific phenomena by starting with a product and asking questions about its functioning. After having studied the scientific principles and laws they learn how these have been applied to the product.

Although the applied science view was meant to make science relevant it has limitations as an approach in technology education. As indicated it disregards the design skills which are essential in technology education. Furthermore Gardner (1999) indicated that it neglects the historical development of technological artefacts. According to De Vries (2006) there are few examples which can show the impact of science to technological innovations which are at the cognitive level of school learners. It means that the science knowledge required to show the impact of science knowledge on technology is complex and therefore handled at a higher level. The other problem with this approach is that applying science is not a straightforward process as described by Layton (1993). He argued that science knowledge would need to be reworked in order for it to be applied meaningfully. In other words for applications of

science to empower learners for purposes of preparing them to intervene effectively in real life the science knowledge needs to be organised in a different form. He suggested four ways in which science knowledge would need to be reworked. These ways are: adjusting level of abstraction, re-packaging knowledge, reconstruction of knowledge and contextualisation (Layton, 1993).

In explaining *abstraction of concepts* Layton (1993), reported that the level of abstraction of concepts that science learners deal with is not normally required in the same form when dealing with technology. Science students are always challenged to adjust the level of abstraction of science concepts when faced with technological issues. For example, the kinetic molecular theory may be used in a science lesson to explain conduction of heat, but the simple fluid flow model could be adequate for a technologist dealing with insulating a house. *Re-packaging knowledge* as indicated by Layton is required because some real life problems and experiences do not match perfectly with organisation of scientific knowledge and pedagogy. That is, what is needed to solve a technological problem may require knowledge from different science disciplines at different levels of abstraction. The science content would therefore need to be reworked in order to solve the problem at hand. The concepts that are used by technologists are sometimes different from those used in science lessons. As a result in some cases when dealing with technological application there is need to introduce new concepts that are more suitable than the scientific concepts. For example, interior lighting designers use concepts such as ‘discomfort glare’ and ‘disability glare’ which are not scientific concepts and are not common in science textbooks. The introduction of these new concepts involves the *reconstruction of knowledge*. He further argued that science teaching has more often depended on simplifying real life situations, and there is need to bring the real contexts of the technological applications when dealing with them. For example in science lessons levers do not bend and a ball rolling down the inclined plane does not experience air friction. *Contextualisation* entails bringing the real life context in dealing with technological application.

The other problem associated with technology as an applied science when used as an approach in technology education is that teachers have not been trained in this approach and they lack the real life experience with artefacts. Cajas (1999) asserts that it is common for many teachers to frame their science teaching around real life problems in teaching topics such as forces and momentum using real life examples such as climbing a rope, accelerating a car, pushing a box and many more. However the educational reforms require that these

applications should be meaningful. This is what teachers find difficult. He suggests that one of the problems is that teachers need to draw from practical knowledge that was not often integrated into their own training. He gave an example of electricity as one topic that has many applications in real life; yet teachers find it difficult to deal with these applications. This is because teachers normally deal with simple circuits in class while real world circuits are more complicated. Furthermore, classroom circuits are meant to develop models which show how electricity works more than to be real circuits found in everyday life.

De Vries (1994) indicated that *the general technological concept approach* like the applied science view does not encourage design and creativity. It often focuses on making learners understand the technological concepts and the processes involved in production. *The design approach* allows learners to make their own designs, make the working pieces and evaluate them. This approach considers aspects of technology such as marketing the products and making manuals for the products. *The key competencies approach* is similar to the design approach but encourages dealing with more analytical problems related to the malfunctioning of products. *The Science/Technology/Society (STS)* is an extension of the applied science approach but is broad in that it also includes the human, social and scientific aspects of technology. The main aim of this approach according to Layton (1993: 43) is to contribute to technological education through technological awareness. This is “awareness of personal, social, moral, economic and environmental implications of technological developments”. According to Gardner (1994) STS approach puts less emphasis on technological capabilities and science content and puts more emphasis on the problematic nature of scientific knowledge. As an approach to technology education it is therefore limited in that it neglects the design skills.

Hofstein *et.al.* (1988), in a paper on the Discussions over STS at the Fourth IOSTE Symposium indicated that there is great interest in STS approach but there are problems and concerns regarding it. They highlighted the following:

- The lack of a clear definition of STS;
- A lack of theoretical structure;
- High esteem accorded to the disciplines of physics, chemistry and biology in their traditional form;
- The unfamiliarity of teachers with the required teaching strategies;
- The nature of STS materials that tends to be fluid and tentative when compared to the ‘clear-cut’ information style of traditional science courses;
- Inadequate curriculum development and implementation procedures;
- Inappropriate techniques and procedures for pre and in-service teacher training;
- A paucity of teaching materials;

- Opposition by boards of examinations, higher education, and politicians;
- The general conservative nature of educational systems (Hofstein *et.al* 1988:359)

The other problem with regard to STS as suggested by Cajas (1999:770) was that “the STS movement has not clarified what learners ultimately learn from their social projects”. As a result of the problems that are facing the STS approach, there are many ways in which the developments of STS materials have emerged. Fenshman (1988) classified courses which follow the STS approach according to what is regarded as the “knowledge of worth” or which of the component of S,T, and S determine the content to be learnt. The “knowledge of worth” in STS materials is determined by either technology, by society or by science.

When the STS approach is technology determined, the “knowledge of worth” is determined by technology. Traditional science content is included but it is not regarded as important. In a science determined STS approach the choice of topic to be studied is based on the sequencing of traditional science topic approach. Science concepts and principles remain the same. The depth of treatment of added STS topics would vary and can be optional. Society determined STS approach is the one in which societal significance of the topic determines what science and what technology is to be included in the materials. Although the STS approach is faced with many problems, Haifa *et.al* (1991) found that there was a difference between learners who have been exposed to STS and those who have not in dealing with STS issues.



As indicated earlier in this chapter, STS approach focuses on technological awareness and lacks design skills which are taken to be the pillars of technology education. However, literature shows many attempts to produce curriculum materials which align with the STS approach. As indicated in Chapter one, examples of projects that have attempted to develop materials which encourage STS approach include: PLON, ALCHEM, SCIENCE PLUS, The Social Consequence of Science and Technology (IST) and many more (Fensham, 1988; Layton, 1993).

Despite all efforts to promote and develop courses and materials using the STS approach, these courses in most cases have remained an option or addition to science. According to Fensham (1988), some of the factors which have contributed to this state of affairs are (1) STS issues usually involve science from different science disciplines which do not normally appear like that in the school science curriculum. For example an issue like “ionizing radiation” could traditionally be a physics topic but under STS it includes other disciplines

such as chemistry and biology especially if it treats issues such as the “Ozone Layer”. (2) In many countries science teachers are specialists in their sciences and do not have the knowledge and the confidence to deal with concepts or arguments that involve economics, politics, religion and others, which are required in dealing with STS. (3) Undergraduate courses in most cases do not deal with controversies in pure science and teaching approaches hardly include discussions on such controversies. In that way, teachers are not comfortable dealing with such arguments.

Generally there are many versions of technology education. In the USA, technology education has grown out of the high school curriculum subject called Industrial arts. Its content of technology is framed around industrial systems such as production, transportation, communication and processes associated with them. In Finland technology has developed around “technical works” and in recent years technology emphasises basic engineering principles, electronics, technical drawing, computer-aided design and manufacturing. In the Netherlands technology has been introduced as a subject and strongly emphasises crafts skills for making functional work pieces. In the UK, technology has moved different phases. It started as crafts; design and technology, then moved to science, technology and society and it then became ‘design and technology’ (Layton, 1993). Technology is still offered as ‘design and technology’ in the national curriculum in Britain.

Putting aside all these approaches, the question is what abilities does technology education strive to attain. Treagust & Rennie (1993) suggested that technology education comprises of four components which are: technological literacy, technological awareness, technological capability and information technology. However, Raat & De Vries (1987) in their research and development of a “Project Physics and Technology” found that experts in technology associated design, ‘working in a practical situation’, and handling technical products with technology. They therefore considered these skills as essential for technology education. In explaining design as an aspect of technology, they indicated that there is a need for learners to be exposed to the processes that come before the production of items or products. The aim of technology education as suggested by Raat & De Vries has been to give learners an opportunity to gain knowledge and principles associated with the use of tools and materials. In the real world learners would be required to handle technical products, which include running equipment, understanding instructional manuals, and carrying out simple repairs. Technology education should prepare learners for such skills. Working in a practical-

technical way as a technological ability gives learners an opportunity to handle materials and tools.

Medway (1993) indicated that technology education is seen as comprising two elements. These are technological capabilities and technological awareness. Technological capabilities include design, use and repair of existing artefacts and systems. Technological awareness involves learners knowing about how different technologies have featured in their social world. It involves examining the cause and the effects of developments of the technological artefacts. According to Medway, other views of technology education take technology education to be “education in, about and through technology” (Medway, 1993:19). *Education in technology* entails acquiring some skills that technologists have. *Education about technology* relates to examining technology in society and *education through technology* deals with doing technology.

In short, it is difficult to define technology since generally its meaning depends on the context in which it is used. In a similar manner technology education is subject to many interpretations. Technology education like other curriculum issues is faced with many competing influences. There are many stakeholders in technology education that have differing views for the inclusion of technology in the school curriculum. These include: the economic instrumentalists, the professional technologists, sustainable developers; girls and women, defenders of democracy and liberal educators (Layton, 1993). Consequently technology education has developed in varied ways globally. However, technology education generally depicts the following approaches: the craft oriented approach, the industrial production approach, the high tech approach, the applied science approach, the general technological approach, the design approach, the key competence approach and the science/ technology/ society approach (De Vries, 1994). Although design is taken to be central to technology education, only the design approach and the key competence approach deal with design capabilities. Other than design, other essential technological abilities that surface in the literature are: ‘working in a practical-technical way’, handling technological products, and technological awareness (Medway, 1993; Raat & De Vries, 1987).

2.4 The science and technology curriculum

There is a relationship between science and technology since some definitions of technology often refer to science (Gilbert, 1992). As shown earlier there are approaches to technology education which bring the connection between science and technology. Examples are technology as an applied science approach and the STS approach. The literature indicates that there are different orientations towards the relationship between science and technology and these orientations have an influence on the science technology curriculum as well as the practices of teachers. According to Gardner (1994), there are four positions, which are held about the relationship between science and technology, which have an influence on curriculum. These are technology as an applied science view, demarcationist view, materialist view, and interactionist view.

Technology as an applied science view asserts that science precedes technology. This means that technological capabilities grow out of scientific knowledge or scientific knowledge generated by scientists provides a basis for the development of technological products (Gardner, 1994; Gardner, 1999). Statements like the one by Bush-the influential American scientist, educator and administrator, (as cited in Gardner, 1994:5) illustrate this view:

Basic research leads to new knowledge ...it creates the fund from which the practical applications of knowledge must be drawn. New products and new processes do not appear full-grown. They are found on new principles and conceptions, which in turn are painstakingly developed by research in the purest realms of science.

Technology as an applied science view most often than not lands itself in curriculum statements, instructional content and teachers' opinion, like it does in public statements like the one shown above. As an approach in the science-technology curriculum it has some limitations. First of all it tells a limited story about the artefact. For example, the operation of the scientific principle is often explained in terms of the scientific concepts that appear in the topic under discussion. This is usually incomplete. Furthermore it neglects design skills, which are normally not considered as scientific knowledge. The motivation for technology under this view is normally to enhance understanding of the scientific principle through a broad range of interesting applications of real life and nothing to do with design. Another consequence of the technology as an applied science view is that it leads to misconceptions of history by taking the technological artefact out of its historical developmental context (Gardner, 1994; 1999).

The demarcationist view suggests that science and technology are different fields; with different goals; and using different methods. Science is taken as a subject that generates knowledge, which is analytical and associated with scholars who seek understanding. Technology deals with design, making, and improving technological artefacts, materials and systems and products that are needed to meet human needs. Supporters of this view show that through historic times, technology has developed independent of science. Currently it is difficult to draw the line between science and technology, as most scientific research happens together with technological developments. Supporters of this view argue that there are many artefacts, which were developed by the process of transmission and evolution of craft knowledge. These artefacts were developed without scientific knowledge. Examples are pottery, plumbing, brewing, windmills, sailing of ships, food preservation etc. The demarcationist view does not always clearly state that there is a difference between science and technology. However, textbooks and other curriculum materials that emphasise pure sciences attest to the fact that there is a difference between science and technology. On the other hand there are some design courses that focus a lot on design and ignore an opportunity to bring in the development of science content purposely. These courses also support the same arguments (Gardner, 1990; 1994; 1999).

The materialist view suggests that technology precedes science. It asserts that technology is historically and ontologically older than science. Many views are put forward for this argument. Examples include the extraction of metals, which came before the understanding of the chemistry associated with them. Optical instruments were also developed before the formulation of the laws of refraction, which explained their operation. This view emphasises the fact that experience with tools, measuring instruments etc. are necessary for the development of scientific knowledge. Curriculum founded upon these arguments provides opportunities for technically skilled learners to acquire relevant scientific knowledge (Gardner, 1990; 1994; 1999).

The interactionist view asserts that the technologists and scientists are groups of people who learn from each other. Those in favour of this view argue that technologists can learn from scientific research or scientists can learn from existing technological artefacts by examining them and improving on them. Sometimes the interaction happens concurrently with the rise of major research centres in some fields such as electronics, biotechnology, computing etc. In modern times, it is very difficult to separate science from technology (Gardner, 1994, 1999).

Bungum (2003) indicated that each of Gardner's positions towards the relationship between science and technology could be easily illustrated through examples which can be found in history and modern science and technology. However, some of the example used for explaining these positions can be used to defend more than one position. Nevertheless, orientations such as the ones shown above have influence on curriculum decisions around the science-technology curriculum. They can further influence teaching practices and the outcomes of the science and technology curriculum. As a result the incorporation of technology into science has been viewed differently in different places. The output of which are the different approaches to the incorporation of science and technology. Gardner (1999: 21) said that: "although these orientations do influence curriculum developers, they do not however dictate the content, how it should be sequenced and many other related issues". He indicated that educators have been trying ways of linking science and technology. The result has been many different approaches to the incorporation of science and technology.

Layton (1993) and Fensham (1988), indicate that science of the early 1960s has been "pure". But the science curricula, which were developed later, had incorporated technology to some extent. This has been done in the form of applications or illustrations of science in action. Layton (1993) shows four different approaches in which technology and science have been incorporated. The four are Science and/ with technology, science of technology, science for technology and science-technology-society (STS). Gardner (1990) suggests five approaches, which he referred to as: Technology-as-an-illustration; cognitive-motivational-approach; and technology-as-an-artefact; technology-as-a-process; and science, technology and society (STS).

Technology-as-an-illustration is the same as science and/with technology. Gardner (1990) shows that in the case of technology-as-an-illustration the technological applications are presented after scientific concepts have been treated. For example, learners are taught electromagnetism through the usual classroom/laboratory atmosphere and then they examine the electric bell as an application to find how it applies the electromagnetism concepts. Layton (1993) refers to this approach as science and/with technology and indicates that this approach is illustrated in programs such as Physics plus, Chemistry plus, and Biology plus. It is also illustrated in physics textbooks such as PSSC by Haber-Schaim *et. al.* (1986).

The cognitive-motivational-approach, according to Gardner (1990), presents technological applications very early in the instructional sequence in order to capture learners' interest in

the topic and then teach the scientific concepts. The aim is to attract student's interest. The early applications can sometimes be treated superficially. This approach is similar to what Layton (1993), calls science of technology. He suggests such applications lead to context-based approaches. Examples can be obtained from Salter's chemistry in Britain and Chemistry in the community (Chem. Com) in the USA.

Technology-as-an artefact as explained by Gardner (1990) involves disassembling artefacts in order to understand the working of the different parts. They could be real or simulated artefacts. Although the scientific concepts are still developed through this method, the central issue is to study artefacts as systems. The scientific concepts to be learned are directed by what the artefact can offer. An example of this approach is when children are asked to disassemble household artefacts in order to understand how they work.

Technology-as-a-process is similar to what Layton (1993), terms science for technology. It is quite different from the other described approaches in that it emphasises the development of technological capabilities. In this approach science is a resource for enhancing problem solving, which is inventing, designing, making etc. Scientific ideas are only relevant if they contribute to the development of these abilities.

Science technology and society (STS) focuses on societal issues and topics with a strong science and technology dimension. The main aim of this approach is to contribute to technological education through technological awareness (Layton, 1993: 43). Gardner (1990) is of the view that this approach puts less emphasises on technological capabilities and science content and puts more emphasises on the problematic nature of scientific knowledge.

In summary there are different orientations to the relationship between science and technology which have influence on the science and technology curriculum. As a result science and technology has been integrated in different ways. In general the approaches which are common in curricula which incorporate science and technology are: technology-as-an-illustration approach, technology-as-an-artefact approach, technology-as-a process approach, cognitive-motivational-approach and STS approach (Gardner, 1990).

2.5 Curriculum

2.5.1 Introduction

The previous section surveyed literature associated with technology education and understandings and ways in which science is integrated with technology. It was found that there are varied meanings associated with technology education and as such technology education curriculum has transformed in varied ways in different places. Some of the approaches used in technology education have led to the incorporation of science and technology. Even then the approaches to the incorporation of technology and science have been diverse. The perspectives and views to technology education have more influence on policy regarding technology education more than curriculum development and practice.

Hence Gardner (1990) argued that technology education is more than arguing for a certain innovation strategy, showing the different orientations and choosing the approaches for integrating science and technology. He indicated that it gets to a point where curriculum developers have to deal with curriculum decisions relating to development such as selecting and sequencing content. Layton (1994: 2) indicated that there are many different innovations suggested for technology curriculum however the “problem tends to arise only when the intended innovation becomes transformed into specific curriculum materials and practices”. Curriculum materials and practices relate to curriculum development and implementation, hence the inclusion of technology into science can be examined through curriculum theory and practice.

2.5.2 What is curriculum?

There are two perspectives to curriculum. Curriculum can be viewed as a plan or the intentions of curriculum developers as depicted in the written document. The other view takes curriculum to be what really happens at school level (Stenhouse, 1988). The view of the curriculum as a plan is concerned with the formal or the official curriculum which is what is planned and documented (syllabus). The perspective that focuses on what actually takes place at school level deals with the actual curriculum which is what the learners actually experience in learning (Graham-Jolly, 2002). However, curriculum study is about the relationship between what is planned and what actually happens (Stenhouse, 1988). As espoused by Kelly (1989), the success between linking theory and practice in curriculum matters relates to the understanding that curriculum studies is about the relationship between intentions and reality. In this relationship:

A curriculum is an attempt to communicate the essential principles and features of an educational proposal in such a form that is open to critical scrutiny and capable of effective translation into practice (Stenhouse, 1988:4).

As indicated the meaning attached to curriculum depends on the individuals' orientation. Curriculum can be defined simply as a syllabus (Kelly, 1989). Conversely curriculum can be taken to include the official document, the purposes, activities, organisation of the program and interactions between the teacher, learners, administrators and other activities that take place in and out of school environment (Walker & Soltis, 2004).

It is therefore common in curriculum circles to come across terms such as the official curriculum which is planned and documented (syllabus) and the actual curriculum which is what the learners actually experience in learning. Kelly (1989) suggested that in dealing with curriculum there is need to adopt the definition, which goes beyond the official curriculum. The definition should include the intentions of the planner, the procedure used in implementing the intentions, the actual experiences of the learner which are the result of teachers' attempts to implement the planners' intentions and the hidden learning that takes place as a result of what the planners have planned. Graham-Jolly (2002) argued that going beyond the definition of curriculum as a syllabus can acknowledge both the intended and the unintended learning, which therefore takes the curriculum as a social construct. He argued that even though a common syllabus can be provided to all schools in a country i.e. South Africa in 1995, any understanding that the common curriculum can be provided to all schools undermines the social differences that exists in schools. Graham-Jolly said that science lessons which are delivered in the rural schools which are not well resourced are not likely to provide an experience similar to those in a middle class suburb which is well resourced.

In short, upon linking theory and practice in curriculum practice it is essential to assume the plan to be a proposal that can be modified in accordance with the circumstances which prevail at school level. This view acknowledges both the intended and the actual curriculum.

2.5.3 Curriculum perspectives

As indicated in Section 2.3.2, technology education is faced with many competing influences. It is possible that the different stakeholders' positions depict their views and perspectives towards curriculum. According to Ornstein & Hunkins (1993) the individual approach to

curriculum shows the individual's holistic position or orientation to curriculum. In support of this view Cornbleth (1990:12) indicated that:

How we conceive of curriculum and curriculum making is important because our conception and ways of reasoning about curriculum reflect and shape how we see, think and talk about, study and act on education made available to learners.

There are other perspectives to curriculum than viewing it as a plan or what actually happens.

According to Eisner (2002) there are five orientations to curriculum that influence the way people think about curriculum. These are: development of cognitive process, academic rationalism, personal relevance, social adaptation, and social reconstruction as well as curriculum as technology. *Development of cognitive process* views the role of both curriculum and teaching as to develop children's ability to learn. This view emphasises the development of children's cognitive capabilities. It is believed that facts and theories have a short life span as they continuously change. Although content is not viewed as important under this view, there are subjects which are regarded as important due to their ability to contribute to the development of cognitive skills. Mathematics is one subject that is regarded as important because of its ability to develop children's ability to reason and to develop a vigorous mind. Related to the issue of cognitive development is Bloom's Taxonomy of educational objectives.

The academic rationalism suggests that there are subjects which are more worthy of study than others. The aim of the school should therefore be to foster the intellectual development of learners in these subjects. Broadening the curriculum to include other subjects, which can be taught out of school, is taken to dilute the curriculum according to this view (Eisner, 2002).

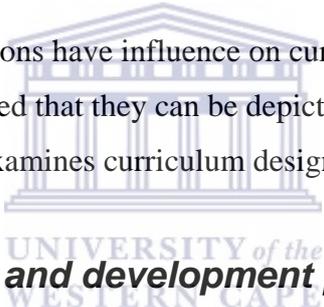
In accordance with the *personal relevance* view, the curriculum has to emerge from the interactions between learners and the teacher. The children have to be given a chance to suggest what they want to learn. The task of the school is mainly to provide a rich environment where children can grow. According to *social adaptation and social reconstruction* the aim of the curriculum has to be based on societal needs. The purpose of the school is to serve the needs of society as the school is an institution, which has been developed to serve society. Some of the needs that the curriculum is sometimes required to address are: manpower needs, conformity to existing values, their needs to find their place in society, and development of social consciousness in children. It has been recognised that in identifying these needs people usually differ (Eisner, 2002).

Curriculum-as-technology concerns curriculum planning and views it essentially as a technical undertaking. Ornstein & Hunkins (1993:2) said this approach

Relies on technical and scientific principles, and includes paradigms, models and step-by step strategies for formulating curriculum usually based on the plan, and sometimes called the blue print or document, goals, objectives and specified content and activities are sequenced to coincide with the objectives, and learning outcomes are evaluated in relation to the goals and objectives.

Eisner (2002); Ornstein & Hunkins (1993); and Stern (1983), agree that these different orientations to curriculum which represent different philosophical positions are not mutually exclusive and do not usually happen in isolation, but it happens that one can dominate. Depending on the context of educational practice, one of the orientations can be handier than others for use, as educational decision need to be made based on the context. Cornbleth, (1990) however stated that the most dominant view is the technocratic conception of the curriculum.

As indicated earlier these orientations have influence on curriculum debates and curriculum making, as such it could be assumed that they can be depicted in curriculum development and design. The subsequent section examines curriculum design and the development process.



2.5.4 Curriculum design and development process

As a noun design refers to the naming and arrangement of the different components of the curriculum. The different components are the aims, goals, objectives, content, learning experiences, and evaluation approaches. As a verb it refers to the process of curriculum making and hence design is sometimes synonymous with curriculum development (Ornstein & Hunkins, 2004).

In respect of the perspective which is held by curriculum developers, the curriculum can be organised along two organisational dimensions. These are the horizontal designs and vertical designs. Horizontal designs involve scope and integration. That is bringing content from different subject areas together. STS is an example of an approach which encourages integration. It integrates science and social science with an attempt to solve practical problems. Vertical designs on the other hand deal with sequence and continuity. The idea of sequence and continuity involves introducing a concept in one grade and reinforcing it or teaching it again in the following grade. Sequencing is an attempt by curriculum developers

to foster cumulative and continuous learning. Sequencing draws from different understandings in education. For example it could be based on subject logic or on Piaget's theory of cognitive development. Sometimes sequencing can depend on the simple to complex learning, whole part learning, prerequisite learning, and chronological learning (Ornstein & Hunkins, 2004).

Sequencing and continuity relate to the concept of spiral curriculum in which previous learning is used as the basis for subsequent learning. The spiral curriculum assumes that for learners to grasp the basics ideas and concepts the ideas and concepts should be developed and be repeated in a spiral pattern increasing both breath and depth as learners progress through the different grades (Ornstein & Hunkins, 1993). The decision on the curriculum design to be adapted by curriculum developers like other curriculum choices is influenced by the curriculum perspectives held by those involved in curriculum development. Hence Ornstein & Hunkins (2004:233) indicated that:

Curriculum design involves philosophical or theoretical issues, as well as practical issues. A person's philosophical stance will affect his or her interpretation and selection of objectives, influence the content selected and how it will be organised, affect decisions about how to teach or deliver the curriculum content, and guide judgements about how to evaluate the success of curriculum development

Ornstein & Hunkins (2004) argued that it is essential that curriculum developers put forward their philosophical and social orientations. They indicated that failure to declare a philosophical stance can result in designs which are limited or confused in rationale. Consequently this can lead to a gap between theory and practice.

On the other hand curriculum development can mainly be viewed from two perspectives, which are the technical/technocratic perspective and the critical perspective. The major difference between technocratic and critical perspectives lies in the way they treat context. Technocratic perspective decontextualizes curriculum operationally and contextually. In other words it separates the syllabus from policy making, design and practice and further detaches curriculum from its context by assuming that curriculum is independent of the educational context in which it is supposed to be practiced. On the contrary, critical approach assumes that curriculum is the product of multiple interacting contexts (Cornbleth, 1990). An example of a technical approach to the curriculum development is the Tyler's model of curriculum development. Walker & Soltis (2004); Posner (2002); Kelly (1989), indicated that the technical model is the most commonly used and the most popular model in curriculum development. Cornbleth (1990) said the examples of the technical approach to curriculum are

the works of Bobbitt, Charter and later Tyler. Following Tyler's model (Tyler, 1949) in curriculum development there are four fundamental questions, which need to be answered by educators in developing the curriculum and these according to Walker & Soltis (2004:56); Jon (2005) are:

What educational purpose should the school seek to attain?

What educational experiences can be provided that are likely to attain these purposes?

How can these educational experiences be effectively organised?

How can we determine whether these purposes are being attained?

Similar questions relating to Tyler's model are espoused by other scholars in the area of curriculum such as Posner (2002); Kelly (1988); and Stenhouse (1988). Tyler's model does not prescribe the aims and objectives for the curriculum but suggests that the aims and objectives should emerge from systematic study of the learners, contemporary life and from subject specialist. The objectives that will have emerged need to be screened against the school philosophy and the psychology of learning. The model further suggests that these objectives should be stated in precise, clear and in specific terms such that they are not ambiguous. The objectives are supposed to guide the assessment. The development of objectives is followed by a description of the learning experiences, which can lead to the attainment of objectives. Then the learning experiences are sequenced in such a way that they allow logical sequence and integration. The last stage is the evaluation stage. The aim of evaluation is to find out if the desired or the intended outcomes have been achieved as planned (Walker & Soltis, 2004; Posner, 2002; Kelly, 1989; Stern, 1983).

The assumptions underlying technical approaches to curriculum development are that:

- Learning is the main purpose of schooling and students are learners, and the objectives have to address the desirable learning.
- Curriculum planning is a scientific enterprise in which curriculum developers can objectively develop desired learning outcomes, without allowing their own orientations to influence the process.
- Curriculum development is a technical matter, more suitably done by technical experts; the matter of deciding instructional methods, and content suitable for addressing certain objectives (Posner, 2002).

According to Posner (2002), examples of curriculum development models which followed Tyler's model are the Taba's model (1962) of curriculum development and Decker Walker's naturalistic model (1971). Taba's model extends Tyler's model by increasing the number of steps to be followed in curriculum development. Decker Walker's naturalistic model is based on good practice in curriculum development but still falls within the family of technical models such as Tyler's model. Walker & Soltis (2004), also mention Schwab's practical and eclectic approach as one of the technical approaches.

Tyler's model to curriculum development is linked with the use of objectives in curriculum development. Objective in the context of curriculum is defined as an aim which describes learners' behaviour. Behavioural objectives are sometimes called intended learning outcomes (Stenhouse, 1988). Ornstein & Hunkins (2004) assert that objectives are written at different levels. They indicated that the first level of writing objectives is the program objectives such as for mathematics or science. The second level of objectives addresses the course, for example algebra. The third level of objectives concerns the classroom objectives which can further be divided into lesson plan objectives. The writing of objectives is influenced by Bloom's Taxonomy (Bloom, 1956). Bloom identifies six levels of cognitive development, which are possession of knowledge, comprehension, application, analysis, synthesis and evaluation. This taxonomy suggests that educational objectives should deal with objectives on each of the levels starting with the lowest, which is the possession of information to the highest cognitive level, which is evaluation. Ornstein & Hunkins suggest that curriculum developers usually develop the objectives at the first and second level while classroom objectives are usually left to teachers.

Objectives can be stated in behavioural and non-behavioural terms. An objective which has been stated in behavioural terms "is a statement of outcomes in terms of observable behaviour expected of learners after instruction" (Ornstein & Hunkin, 1993:217). The issue of stating objectives either in behavioural terms or non behavioural terms has been debated largely in curriculum circles. Some scholars who have contributed to this debate include Stenhouse (1988), Macdonald-Ross (1985) and Eisner (2002).

Criticisms raised against stating objectives in behavioural terms include the following:

- Trivial learning behaviours are the easiest to state in behavioural terms; hence many important educational outcomes may drop out in an attempt to state them behaviourally.

- Objectives pre-specified in behavioural terms may prevent teachers from taking advantage of unexpected learning opportunities that may arise in the classroom.
- Behavioural objectives neglect other educational outcomes which might not have been intended such as parental attitudes and other outcomes related to professional staff and the community.
- Behavioural objectives are considered undemocratic since they plan in precise terms what one should learn before instruction
- Behavioural objectives work against teachers' practice as teachers rarely state their classroom objective in behavioural terms (Stenhouse, 1988; Macdonald-Ross, 1985).

In summary Eisner (2002) argued that:

Curriculum theory as it pertains to educational objectives has four significant limitations. First, it has not sufficiently emphasised the extent to which the prediction of educational outcomes can not be made with accuracy. Second, it has not discussed the ways in which the subject matter affects precision in stating educational objectives. Third, it has confused the use of educational objectives as a standard measurement when in some areas it can be used only as a criterion for judgement. Fourth, it has not distinguished between the logical requirements of relating means to ends in curriculum as a product and psychological conditions useful for constructing curriculum (Eisner, 2002:90).

As indicated the other view to curriculum development is the critical perspective. Paulo Freire's work is suggested in the literature as the illustration of the critical perspective (Walker & Soltis, 2004; Posner, 2002). According to Walker & Soltis (2004), Paulo Freire's work on curriculum development is geared towards stimulating and sustaining consciousness in people. Posner (2002) describes Paulo Freire's approach as the emancipatory approach. He said this approach emphasises critical reflection based on one's concrete situation. In developing curriculum based on critical consciousness the following are the steps to be followed:

First, the team of educators helps the people in a particular place to develop 'generative themes' (e.g. culture, under-development, alcoholism) that represent their views of reality.

From this set of themes, a group of professional educators and non-professionals, local volunteers, through 'dialogue', cooperatively identify themes to be used for curriculum and develop instructional materials for each of them.

Then the materials are used in 'culture circles' as the focus of discussions. The materials, including readings, tape-recorded interviews, photographs, and role-plays,

are designed to reflect characteristics of the people's lives and thus, to stimulate critical reflection about lives.

Ultimately this process leads to 'praxis', action based on 'critical reflection', the goal of Freire's pedagogy (Posner, 2002:56).

In general terms the critical consciousness approach does not put the experts at the fore front. This perspective questions the authority of the curriculum developer upon deciding on what should be taught. According to the critical consciousness approach, curriculum planning is not a technical matter but a political and ideological matter. It therefore challenges the idea of reducing the curriculum development to a technical procedure. Furthermore, the product of curriculum planning is not learning outcomes but reflections on how to act on social realities. It encourages the involvement of the teacher and the learners in decision-making regarding what should be learned. It is a democratic process, which is not value free, but involves political and ideological matters (Posner, 2002).

In summary curriculum orientations influence the way individuals deal with curriculum matters. Technology inclusion in the school curriculum is prone to such influences. This is because the design model, development procedures and strategies for evaluating the curriculum used in a curriculum process depends much on the curriculum developers' perspectives of curriculum. As Ornstein & Hunkins (1993) put it, the individual's philosophical position influences the way the individual interprets, selects, and organises content. The viewpoints also guide decisions regarding teaching and evaluation of the curriculum.

2.5.5 Curriculum evaluation

Stake (2004) describes evaluation research as the research that makes systematic effort to discover the activity, meanings and values of an entity, with the aim of searching for quality and generalisation. Related directly to curriculum evaluation Hamilton (1976) defined curriculum evaluation as the process used to weigh the relative merits of an educational alternative, which is taken to be part of a curriculum practice. Although Ornstein & Hunkins (1993) argued that there is no consensus regarding the definition of curriculum evaluation they said evaluation is a process or processes used to gather data in order to make decisions. The focus of evaluation according to Ornstein & Hunkins (1993) is to establish whether curriculum designs, curriculum development and implementation are producing what they intended to achieve. The purpose of evaluation according to the two authors is to allow stakeholders in curriculum to revise, compare, maintain, or discontinue the programme.

Ornstein & Hunkins (1993) classified curriculum evaluation models into scientific and humanistic evaluation models. The former includes those curriculum evaluation models that favour objective experiments and concentrate their efforts on learners. Scientific approaches use mainly quantitative methodologies and data is analysed using statistics. On the other hand humanistic curriculum evaluation models use qualitative and sometimes a combination of both qualitative and quantitative approaches. The focus of data collection is on observations made in the actual setting. Data for this approach can also be collected through interviews and discussions. Data collected in interviews form data, which are presented as patterns that are later presented in 'thick' descriptions in the reports. They also suggested that the models could be utilitarian or intuitionist. The evaluation model is utilitarian if it looks at a large number of individuals, and intuitionist if it focuses on individual or small groups. They further indicated that the curriculum evaluation model could be formative or summative. Evaluation is formative if it is meant to improve a program while the programme is still at its developmental stage. It is summative if it aims at getting the whole picture about the programme and usually takes place after the programme is completely developed and has reached the implementation stage.

Ornstein & Hunkins (1993) classified the following evaluation models as scientific: Metfessel and Michael Evaluation model; Provus's Discrepancy Evaluation Model; Stake's Congruency-Contingency Model; Stufflebeam's Context, Input, process, Product Model; and Judicial Approach to Evaluation Approaches. Ornstein & Hunkins cited the following as the humanistic approaches to curriculum evaluation: Eisner's Connoisseurship Evaluation Model; Stake's Responsive Evaluation Model; Parlett and Hamilton Illuminate Model; and Lightfoot's Portraiture Model. This is by no means the only classification of the curriculum evaluation approaches. Stufflebeam and Shinkfield (1985) referred to some of these models as systematic evaluation approaches and they gave the following as examples: The Objective-Oriented Evaluation approach; The Tylerian Tradition, Stufflebeams' Improvement Oriented Evaluation (commonly known as the CIPP Model), Stake's Client Centred Approach to Evaluation, Scriven's Consumer Oriented Approach to Evaluation.

There is a whole shopping list of curriculum evaluation models. The task is to select the most appropriate. According to Kelly (1986) the type of curriculum evaluation model chosen to evaluate curriculum needs to be related to the curriculum planning model. Stake's responsive evaluation model/ Stake's congruency-contingency model has been chosen as the basis for collecting empirical data and a guide in the analysis of data in this study for this reason.

Stufflebeam and Shinkfield (1985) said Stake's congruency-contingency model of educational evaluation which was later developed to Stake's Responsive Evaluation model is built on the Tylerian concept of curriculum evaluation, where the emphasis is on the comparison between what was intended and what was observed to be the outcomes. However, Stake expanded his evaluation procedures to include investigating the background, standards, and judgements as well as outcomes. Stufflebeam and Shinkfield (1985: 209) showed that the Responsive Evaluation Model still incorporated the concepts in the Countenance Model but

it broke sharply from the Tylerian tradition of gathering data to discuss whether intentions had been realised. Instead, the Responsive Evaluation Model assumed that intentions would change and called for continuing communication between the evaluator and the audience for the purposes of discovering, investigating, and addressing issues'

According to Stake (1967:13):

Responsive evaluation will be particularly useful during the formative evaluation when the staff needs help in monitoring the program, when no one is sure what problems will arise. It will be particularly useful in summative evaluation when audience want an understanding of a program's activities, its strength and shortcomings, and when the evaluator feels that it is his responsibility to provide a vicarious experience.

Stake's model is represented in the form of a matrix. The matrix suggests the type of data to be collected and ways in which data can be analysed. The matrix is as shown in Figure 2.

The important aspects of the model are:

Antecedents: that is any condition existing prior to teaching and learning, which may relate to outcomes. Examples might include environmental factors, school procedures or pupil's interest or prior learning.

Transactions: such as the interaction that occurs between teachers and pupils, pupils and pupils, pupils and curriculum materials and tasks or pupils and the physical, social and educational environment

Outcomes: which are to be interpreted in the widest sense include outcomes that are "immediate and long range", cognitive, personal and community-wide, (Stakes, 1967)

Intents		Implemented
Intended antecedents: What is assumed to exist before teaching and learning that may relate to outcomes	← Congruency →	Observed antecedents: What actually exist before teaching and learning that may relate to outcomes
↑ Logical contingency ↓		↑ Logical contingency ↓
Intended transactions: Planned instruction	← Congruency →	Observed transactions: Transactions that actually happened
↑ Logical contingency ↓		↑ Logical contingency ↓
Intended outcomes : What was intended to be achieved	← Congruency → 	Observed outcomes: What was achieved, intended or unintended

(McCormick and James, 1988:178)

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Figure 2 Stake’s matrix for guiding data collection and analysis

In using this matrix, the main task of evaluating is to establish the relationship between any two of the cells of the matrix. The analysis of data derived as a result of following the matrix requires understanding of two more concepts. These concepts are contingency and congruence. Logical contingency is defined as the assessment of how far the intentions related with antecedents and are logically coherent with those regarding transactions and outcomes. The relationship between planned and observed data concerns congruency. Although Stake’s congruency-contingency Model emphasises curriculum in action, it does not reject input and output data (Beck & Yeoman, 1987; McCormick & James, 1988).

2.6 Summary

The literature indicates that the current goal for science education is to provide science for all. It is in response to this goal that there are global initiatives to include

technology in the school curriculum. However, technology and consequently technology education has diverse meanings. Furthermore there are many competing views and influences on technology education. As a result technology education has been included in the school curriculum in many different ways.

The arguments surrounding the inclusion of technology in the school curriculum tend to focus on suggesting certain innovation strategies. Most often curriculum decisions relating to development such as selecting and sequencing content are neglected. Consequently problems become more prominent when the intended innovations have to be translated into specific curriculum practices.

The subsequent chapter outlines the theoretical framework of the study. It outlines curriculum theory; in particular it discusses curriculum development, design and evaluation. It further discusses issues relating to technology and technology education.



3. Theoretical framework

3.1 Introduction

This chapter outlines the theoretical framework of the study. It presents Stake's (1967) congruency-contingency model which is used as the main theoretical framework for the study. Stake's model only serves as a guide in the collection and analysis of data. The chapter further discusses the constant comparative approach (Merriam, 1998) which is used in the detailed analysis of qualitative data. It also highlights Gardner's (1994) approaches to the incorporation of science and technology and theory relating to curriculum development, design and evaluation as advocated by scholars such as Ornstein & Hunkins (2004) and Stenhouse (1988) and Kelly (2004). Both the field of technology education and curriculum are broad and no attempt is made to cover them entirely. The selected areas are those that can serve a purpose in the collection and analysis of data in this study.

3.2 Curriculum theory

3.2.1 *What is curriculum?*

As indicated in Chapter Two, curriculum may be viewed as a plan or intentions. On the other hand it may be assumed to be what actually takes place at school level as the plan is being implemented. It is therefore common in curriculum circles to come across terms such as the official curriculum which is planned and documented (syllabus) and the actual curriculum which is what the learners actually experience in learning (Graham-Jolly, 2002). However some scholars in the field of curriculum such as Kelly (2004) and Stenhouse (1988) argue that curriculum study is about the relationship between the intentions and practice. Hence curriculum may be taken to include the official document (syllabus) which depicts the planned curriculum, procedures used to implement the plan and actual experience of the learners. This study is based on the understanding that there is an intended and the actual curriculum and the relationship between them constitute a curriculum.

3.2.2 Curriculum Development

As outlined in Section 3.1.1, there are two perspectives in curriculum. Curriculum development is also viewed from two perspectives, which are the technical/technocratic perspective and the critical perspective.

Technocratic perspective aligns with the view of curriculum as a plan. Cornbleth (1990) suggested that the technocratic perspective of curriculum decontextualises curriculum operationally and contextually. She indicated that the technocratic perspective to curriculum separates curriculum from its context by assuming that curriculum is independent of the educational context in which it is supposed to be practiced. In other words those who emphasise the curriculum plan in developing the curriculum align with this view. An example of a technical approach to curriculum development is Tyler's (1949) model of curriculum development. According to the literature this model is the most commonly used and the most popular model in curriculum development (Walker & Soltis, 2004; Posner, 2002; Kelly, 1989).

The technocratic perspective to curriculum development is associated with the behavioural approach. It uses step-by-step strategies for developing curricula. It involves development of goals and objectives, and it further specifies content, learning outcomes and activities (Ornstein & Hunkins, 1993). It assumes that curriculum development is a technical matter which is best done by curriculum developers (Posner, 2002).

The critical perspective on the other hand assumes that curriculum is the product of multiple interacting contexts (Cornbleth, 1990). The critical perspective to curriculum development is illustrated by the work of Paulo Freire (Walker & Soltis, 2004; Posner, 2002). This approach questions the authority of the curriculum developers in deciding what should be taught. Consequently this perspective encourages the involvement of teachers and learners in decision making regarding what should be taught. Those who follow this perspective do not believe curriculum development can be reduced to a procedure (Posner, 2002).

3.2.3 Curriculum design

Even though curriculum perspectives may differ, there are generally two ways in which curriculum may be organised. Curriculum can follow a horizontal design or a vertical design. The horizontal design is associated with integration of different subject areas. Vertical designs on the other hand focus on sequence and continuity which is an attempt to encourage

cumulative and continuous learning. This approach can result with students experiencing more demanding content as they move through the grades (Ornstein & Hunkins, 1993; Parkay *et.al*, 2006). The views to curriculum have an influence on curriculum design, development, and implementation. The perspectives to curriculum can therefore guide the analysis of data when evaluating a curriculum.

3.2.4 Curriculum evaluation

Curriculum evaluation is meant to establish whether curriculum designs, curriculum development and implementation are producing what they intended to achieve. It allows stakeholders in curriculum to revise, compare, maintain, or discontinue the programme Ornstein & Hunkins (1993). There are many models for evaluating the curriculum. However the one that has been adopted for this study is Stake's (1967) congruency-contingency model.

Stake's Contingency-Congruency model

Stake's (1967) model attempts to address the relationship between the intended curriculum and what actually happens at classroom level (Stenhouse, 1988). The model investigates congruency between the intended and the implemented curriculum. According to this model congruency between the intended curriculum and the implemented curriculum is investigated at three levels. These are at the level of the antecedents, transactions and outcomes.

McCornick & James (1988) referred to antecedents as any condition which exists before teaching and learning which can relate to outcomes. These may include environmental factors, learners' prerequisite knowledge, teacher training and many more. Transactions according to the same authors refer to interactions which take place between teachers and learners, learners themselves, learners and the physical, social and educational environment. According to Ornstein & Hunkins (2004), the outcomes concern the products, especially performance. McCornick & James (1988) indicated that outcomes can be immediate and long range and they can be cognitive, personal and community wide. The other important aspect of this model concerns the assessment of logical contingency. McCornick & James (1988) defined logical contingency as the assessment of how far the intentions relate with antecedents and are logically coherent with those regarding transactions and outcomes.

Stake's model is represented in the form of a matrix as indicated in Chapter Two. This matrix suggests the type of data that can be collected and how it could be analysed in evaluating a curriculum. However this model has been adopted for it to relate to the research questions for this study. The adopted model is as in Figure 3.

The nature of the Intended Curriculum

The nature of the implemented curriculum

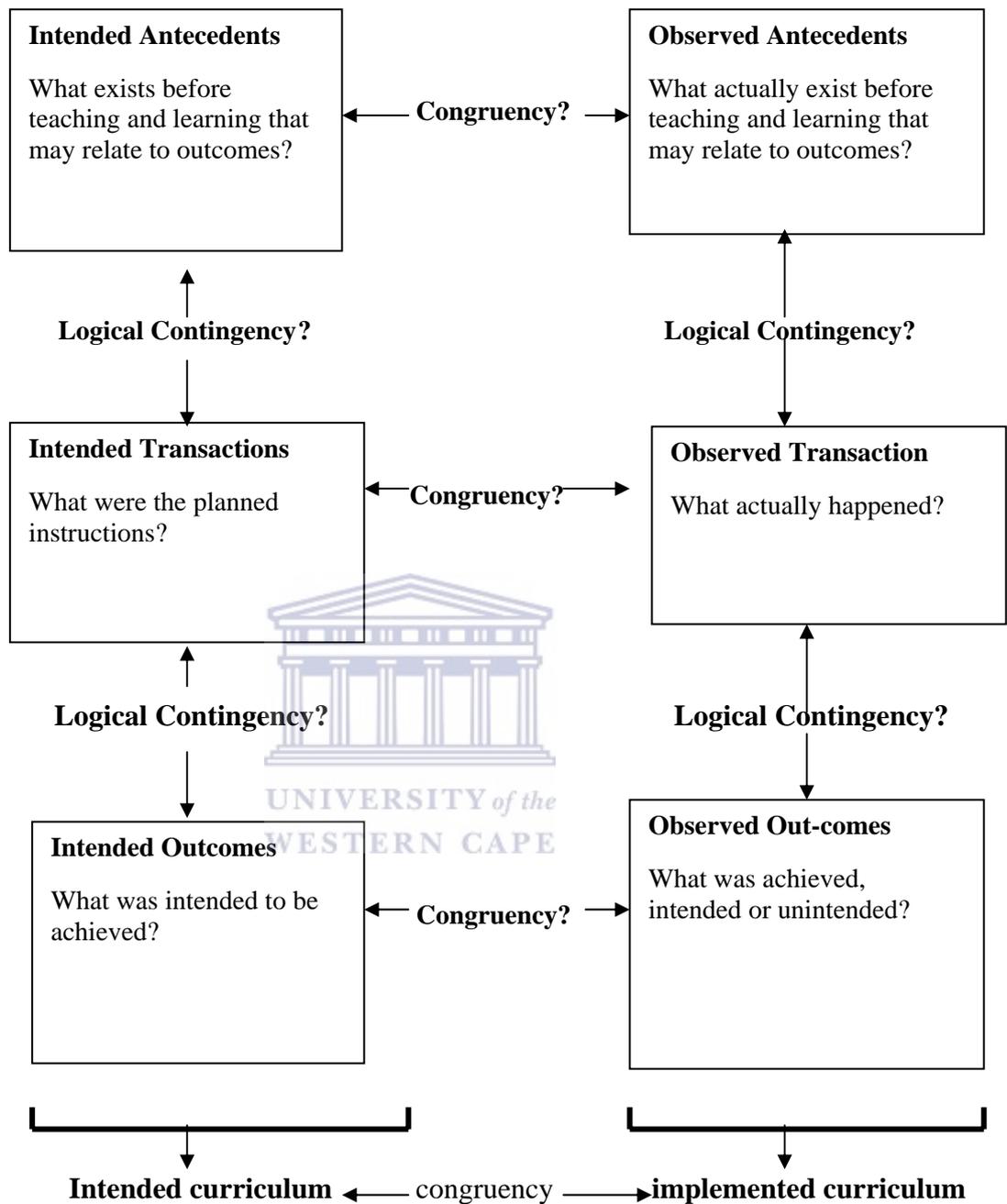


Figure 3 Modified Stake's (1967) Model

The first research question which relates to the nature of the new Lesotho junior science-technology curriculum was mainly investigated based to the component of Stake's model which deals with the intended curriculum. The intended curriculum was searched for coherence at three levels which are the antecedents, the transactions and the outcomes. The

intended curriculum was investigated by analysing the curriculum materials. These are the syllabus, the textbook and the examination questions papers.

The second research question which examines how the new science-technology curriculum was implemented in the classroom was investigated using the component of Stake's model that relates to the implemented curriculum. Like in question one, consistency across the observed antecedents, transactions and outcomes was investigated. Furthermore, the observed antecedents, transactions and outcomes were each compared with intended antecedents, transactions and outcomes.

Although the study deals with the antecedent, transactions and outcomes and their contingencies, it puts more emphasises on the antecedent and transactions. The aim is still to establish how the curriculum developers' plans are being carried out and what challenges they are faced with under the conditions that prevail at school level. The evaluation that is planned in this study is a single program. The aim of the study is not to compare the curriculum under investigation with any other curricula. As a result no attempt is made to compare the program under evaluation with any other external standards or another program.

In summary, Stake's model is used in this study to guide the collection and analysis of data. As indicated in the introduction, the framework for the study draws from other theoretical areas such as the constant comparative approach (Merriam, 1998) which is used in the analysis of detailed qualitative data.

3.3 Constant comparative approach

The constant comparative approach was used by Glaser and Strauss as a method of developing grounded theory (Merriam, 1998; Macmillan & Schumacher, 2001). In describing this approach to analysis of qualitative data, Merriam (1998:179) indicated that it "does just what its name implies and that is to constantly compare".

The constant comparative approach involves different levels of analysing and presenting findings. The lowest level is the descriptive account, the next level is the level of category construction and the last is analysis which involves making inferences, developing models, and generating theory. Merriam (1998) and Neuman (2003) said qualitative analysis involves categorising data, developing conceptual definitions and examining the interrelationship among the concepts. This process involves three processes, which are open coding, axial coding and selective coding. Open coding is usually used as the first attempt to reduce the

data. It involves identifying themes and assigning initial codes to them. Axial coding normally happens when the researcher goes through the data for the second time. At this stage the researcher focuses on the initial codes that were formed during open coding. New codes may emerge during this stage but the task has now moved to the level of organising ideas or themes and identifying key concepts. Neuman (2003:444) said, “during axial coding, the researcher asks about causes and consequences, conditions and interactions, strategies and processes, and looks for categories or concepts that cluster together”. After axial coding the researcher then moves to the more abstract analysis, which involves identifying major themes of the research study selectively looking at the concepts that illustrate themes, comparing and contrasting between the themes.

3.4 Technology education curriculum

3.4.1 Technology education

This evaluation study is situated within technology education. In order to understand the nature of the Lesotho science-technology curriculum, the framework for the study draws on understandings, views and perspectives of technology education. Specifically, Gardner’s (1990) approaches to the integration of science and technology are used in guiding analysis of data related to technology education.

As indicated in Chapter Two, technology and consequently technology education does not have a common meaning. Technology is a fluid term whose meaning depends much on the context in which it is used. On the other hand there are varied views and orientations towards the inclusion of technology in the school curriculum. Although there are many orientations and views towards technology education they do not directly deal with issues that relate to curriculum development. For example, the orientations do not suggest the content standards (Parkay *et.al*, 2006), and arrangement of content. As a result developments and transformations in technology education have taken a variety of forms in different places (Layton, 1994).

However, De Vries, (1994) indicated that there are common approaches to technology education. The common approaches to technology education as espoused by De Vries (1994) are summarised as in Table 1.

Table 1 *The common approaches to technology education and the competencies they encourage*

Approaches to technology education	The competences encouraged by the approach
Craft oriented approach.	Takes technology education as an introduction to vocational training, hence encourages the development of crafts skills.
Industrial production approach.	Encourages learners to produce working pieces and promotes the understanding of how products are made in industry.
High tech approach.	It is production oriented but focus on learners' use of high-tech equipment such as computers.
Applied science approach.	Encourages learners to learn scientific principles and laws and then relate them to the products.
General technological approach.	Focuses on making learners understand the technological concepts and the processes involved in production.
Design approach	Develops learners' ability to make their own designs, make the working pieces and to evaluate products. It further encourages learners to develop abilities to market and make manuals for the products.
Key competency approach.	It is similar to design approach but encourages dealing with more analytical problems related to malfunctioning of products.
Science technology and society (STS)	It is an extension of the applied science approach but also includes the human, social and scientific aspects of technology.

The approaches to technology education as depicted in Table 1 indicate that these different approaches do not have the same focus. However there are those approaches which relate science to technology. The examples for such approaches are the STS approach and the applied science approach. The approaches to technology education

that relate science and technology are used in explaining some of the data collected in the study.

The literature in technology education indicates that design is central to technology education. Other than design the essential technological abilities that surface in the literature are: 'working in a practical-technical way', handling technological products, and technological awareness (Medway, 1993; Raat & De Vries 1987).

3.4.2 Science and technology education

As indicated in Section 2.4, among all of approaches to technology education only two approaches seem to show a relationship between science and technology. These are technology as an applied science and, technology and society (STS). Scholars in technology education show that technology as an applied science and STS approach have limitations as approaches to technology education since they neglect design skills (Layton, 1993; De Vries, 1994; Gardner, 1999).

The applied science approach and the STS approach suggest that there is a relationship between science and technology. As shown in Chapter Two there are different orientations towards the relationship between science and technology and these orientations have an influence on the science technology curriculum as well as the practices of teachers.

According to Gardner (1994), there are four positions about the relationship between science and technology which have an influence on curriculum. These are technology as an applied science view, demarcationist view, materialist view, and interactionist view.

Technology-as-an-applied-science view asserts that scientific knowledge generated by scientists is the basis for technological developments (Gardner, 1994). *Technology-as-an-applied-science* view most often than not lends itself in curriculum statements, instructional content and teachers' opinion. When adapted as an approach to technology education curriculum, it has limitations. First of all it neglects design skills which are regarded as central to technology education (De Vries, 1994; Layton, 1993; Gardner, 1999). Secondly this approach tells a limited story about the artefact. The motivation for technology is usually to enhance an understanding of the scientific principle through a broad range of interesting applications of real life. Consequently this leads to misconceptions of history by taking the technological artefact out of its historical developmental context (Gardner, 1994; Gardner, 1999). Thirdly there are very few examples which can show the impact of science to

technological innovations which are at the right cognitive level of school learners. These examples correspond with science content at a higher level of education (De Vries, 2006). Lastly Layton (1993) argues that applying science is not a straightforward process as assumed. In most cases science content needs to be reworked in order for it to be applied in everyday life.

It is difficult today to draw the line between science and technology, as most scientific research happens together with technological developments. However those who hold the *demarcationist* view suggests that science and technology are different fields. They suggest they have different goals and use different methods. They perceive science as a subject that generates knowledge which is analytical and associated with scholars who seek understanding. They associate technology with design, improving and making technological artefacts; materials; systems and products that are needed to meet human needs. Their separation of technology and science is based on the fact that technology through historic times has developed independent of science. Supporters of this view give many examples of artefacts which were developed by the process of transmission and evolution of craft knowledge. They argue that the development of these artefacts was not based on scientific knowledge (Gardner, 1990; 1994; 1999).

There are textbooks and other curriculum materials that emphasise pure sciences and design courses that focus a lot on design and ignore an opportunity to bring in the development of science content deliberately. Although they do not explicitly show that there is a difference between science and technology, they do however, show and encourage this separation. These courses in essence support the demarcationist view (Gardner, 1990; 1994; 1999).

The *materialist view* emphasises the fact that experience with tools, measuring instruments etc. are necessary for the development of scientific knowledge. As such technology came before science. There are many arguments that are put forward for this argument. Examples include the extraction of metals, which came before the understanding of the chemistry associated with them. Curriculum founded upon these arguments provides opportunities for technically skilled learners to acquire relevant scientific knowledge (Gardner 1990; 1994; 1999).

The *interactionist view* opposes demarcationist view in that it does not suggest the separation between science and technology. Those who follow the interactionist view believe that the technologists and scientists are groups of people who learn from each other. Those in favour

of this view argue that technologists can learn from science research or scientists can learn from existing technological artefacts by examining them and improving on them. Currently the interaction between science and technology has resulted in a rise of major research in some fields such as electronics, biotechnology, computing, etc. As such in modern times, it is not easy to separate science from technology (Gardner, 1999).

3.4.3 Approaches to the incorporation of science and technology

Layton (1993) asserts that there are four different approaches in which technology and science are incorporated. The four are science and/ with technology, science of technology, science for technology and science-technology-society (STS). Gardner (1990) suggests five approaches, which he refers to as: technology-as-an-illustration; cognitive-motivational-approach; and technology-as-an-artefact; technology-as-a-process; and science, technology and society (STS).

Technology-as-an-illustration approach is the same as science and/ with technology. In this approach technological applications are presented after scientific concepts and principles have been treated. For example, the teacher may teach magnetism, magnetic induction, temporary and permanent magnets, as well as electromagnetism to learners using the usual laboratory/classroom approach. After presenting the physics concepts the teacher may illustrate these concepts using the electric bell (technological artefacts). The electric bell may be disassembled to demonstrate the working of the electromagnet (Gardner, 1990).

The cognitive-motivational-approach, according to Gardner (1990), presents technological applications very early in the instructional sequence in order to capture learners' interest in the topic. For example, the teacher may disassemble an old TV set (technological artefact) to show learners an electron tube. The learners are motivated towards learning about the working of a television. However the focus of the teacher may not be on the electron tube. The teacher in this case may put the artefact aside and go back to teach about deflection of electrons in the tube. The teacher may make very little reference to the electron tube or not at all. The aim of using the artefact is to attract student's interest. As indicated by Gardner the early applications can sometimes be treated superficially.

Technology-as-an-artefact as explained by Gardner (1990) involves disassembling artefacts in order to understand the working of the different parts. They could be real or simulated artefacts. For example, the teacher could ask learners to disassemble the cooling system of a

car engine looking at the component parts, showing how they work and relating them to scientific principles such as methods of heat transfer. Although the scientific concepts are still developed through this method, the main concern is to study artefacts as systems. The scientific concepts to be learned are directed by what the artefact can offer. An example of this approach is when children are asked to disassemble household artefacts in order to understand how they work.

Technology-as-a-process is similar to what Layton (1993), terms science for technology. In this approach science is a resource for enhancing problem solving, which is inventing, designing, making etc. Scientific ideas are only relevant if they contribute to the development of these abilities. Historical development, case studies and problem solving are central to the process. For example, learners may be required to look at the historical developments of the steam engine. What brought about the need to design the steam engine, the process of inventing it, and problems encountered. Learners may further be required to investigate about the steam engine. They may also be asked to design or improve on a given model of the steam engine.

Science-technology-society (STS) focuses on societal issues and topics with a strong science and technology dimension. Layton (1993: 43) said the main aim of this approach is to contribute to technological education through technological awareness, that is, “awareness of personal, social, moral, economic and environmental implications of technological developments”. Gardner (1990) said this approach puts less emphasis on technological capabilities and science content and puts more emphasis on the problematic nature of scientific knowledge. For example, learners may be required to examine the building of a borehole pump for the village. There is a technological artefact at the centre of the project but there are other issues such as maintenance, health hazards, economic factors, durability, sustainability, management of the borehole and many other related issues which learners are challenged to look into.

The approaches to the incorporation of science and technology suggested by Gardner (1990) which have been discussed above have been used as bases for investigating the nature of the intended Lesotho science-technology curriculum. That is the syllabus document, the , and the curriculum developers’ perceptions of the aim of the science and technology curriculum. Similar understandings were also used in analyzing classroom interactions where applicable.

It was anticipated that some teachers are likely to teach science without attempting to integrate technology. In order to accommodate cases like this a fifth category was included which allowed the classification of instances where there was no attempt to include technology. For example, teaching magnetic field, demonstrating it with the iron fillings and bar magnets with no reference to any technology.

3.5 Summary

The conceptual framework for this study is underpinned by the understanding that there is an intended curriculum and the actual curriculum. The assumption is that the intended curriculum is likely to be modified at school level as teachers try to interpret the intentions of curriculum developers (Ogunniyi, 1996). Stake's congruency-contingency model by its nature of investigating the congruency between the intended curriculum and the implemented curriculum as well as logical contingency among the intentions and the implemented curriculum, is taken to be the main theoretical framework for this study. It is used in guiding the collection and analysis of data.

However, Stake's model only serves as a framework for organising collection and analysis of data. The constant comparative approach is therefore used in analysing the qualitative data (Merriam, 1998). Furthermore the researcher recognised that some of the issues relating to the inclusion of technology into the science curriculum can best be explained by the approaches used in incorporating science and technology; hence Gardner's (1990) five approaches to the incorporation of science and technology have been used in the analysis of data. Parts of curriculum theory especially curriculum design and development that were found relevant to the study have also been used in analysing data.

The next chapter describes the methodology adopted in the study. It also discusses the methods used in collecting data and how the data were analysed.

4. Methodology

4.1 Introduction

The purpose of this study is to evaluate the new Lesotho Junior Science-Technology Curriculum (LJSTC). In specific terms the study aims to assess the nature of the planned and the implemented LJSTC. The planned curriculum refers to the official curriculum. The implemented curriculum denotes the actual curriculum that was experienced by learners as teachers tried to interpret the intentions of curriculum developers (Graham-Jolly, 2002). As indicated in Chapter One this study is guided by the following questions:

1. What is the nature of the planned junior science-technology curriculum emphasis?
2. What is the nature of the implemented junior science-technology curriculum emphasis?
 - (a) What is the nature of teacher training relative to the implementation of the science-technology curriculum emphasis?
 - (b) What are science teachers' perceptions of science-technology inclusion?
 - (c) What is the nature of the teacher-learner-material interaction?
 - (d) What are the outcomes of the science-technology curriculum?

The first question investigated how curriculum developers envisaged science-technology incorporation into curriculum as well as how the planned curriculum was portrayed in the curriculum materials. The second question tried to establish how teachers and learners interpreted the plan and implemented it under the circumstances which prevailed at school level. This question addressed issues such as teachers' perceptions of the inclusion of technology, teacher training and nature of teacher-learner-material interactions. The study used document analysis, interviews, classroom observations, and achievement tests as strategies of collecting data. The research design that was adapted for the study was a multiple site case study involving four schools out of two hundred and ten secondary schools in Lesotho.

This chapter explains how the study was conducted. It includes the description of the research design, the setting, the procedure for selecting informants, the measuring

instruments, and the procedure for collecting and analysing data. Other information that was found applicable in the conduct of this study such as the pilot procedure, issues of reliability and validity as well as ethical considerations have also been included in the chapter. The chapter concludes by highlighting the limitations of the study

4.2 Research design

The purpose of this study as indicated was to evaluate the new LJSTC. As such this study is an evaluation study. Evaluation research makes systematic effort to discover the activity, meanings and values of an entity, with the aim of searching for quality and generalisation (Stake, 2004). In relating evaluation research to education, Stenhouse (1988:112) indicated that:

Evaluation is the process of conceiving, obtaining and communicating information for the guidance of educational decision making with regard to a specific programme.

The programme that has been evaluated in this study is the curriculum. As a result this study can be classified as curriculum evaluation research. In defining curriculum evaluation, Hamilton (1976) said it is the process used to weigh the relative merits of an educational alternative, which is taken to be part of a curriculum practice.

This study evaluated curriculum policy in Lesotho. The study investigated the nature of the curriculum policy and how it was implemented in secondary schools in Lesotho and hence the research design adapted for this research was a case study. However, in order to investigate the case, multiple sites were identified which could allow the researcher to understand the big case in question. Four secondary schools were selected as sites where in-depth study of curriculum implementation could be observed. According to Merriam (1998) the idea of bringing multiple cases, especially with variation across cases is a common strategy for enhancing external validity or the ability to generalize the findings of the study.

This study was oriented more towards qualitative research; however it used both quantitative and qualitative methodologies for collecting and analysing data. Strauss & Corbin, (1998) described quantitative research as a methodology that uses statistical procedures and other methods of quantifying to reach findings. They defined qualitative research as research that produces findings by nonmathematical processes. In relating qualitative and quantitative

methodologies to evaluation research, Stake (2004:2) refers to the two as interpretive evaluation and criterial evaluation respectively:

Criterial evaluation is the determination and representation of quality using numbers and scales-that is, with criteria. It is quantitative evaluation-more objective, analytical, and standards-based. Interpretive evaluation is determination and representation of quality through subjective experience, using verbal description. It is qualitative evaluation-more episodic and holistic.

The most common methods for collecting data in qualitative research are observations, interviewing, and document analysis (Ary *et al.*, 2002). The strategies of collecting data that were used in this study were interviews, classroom observations, document analysis and tests. Multiple sources were used in order to enhance the validity of the findings and to allow cross checking. Merriam (1998) and Macmillan & Schumacher (2001) indicated that information from only one source cannot be trusted to give a comprehensive interpretation of results. The research approaches which were used in this study are summarised in Table 2.



Table 2 Aspects of the research processes and the approaches used to study them.

Research processes	The approach adapted in the study
Research design	Mainly qualitative-case study with multiple sites.
Theoretical orientation	<ol style="list-style-type: none"> 1. Stake's model for guiding collection of data 2. Constant comparative approach for analysis of data. 3. Gardner's (1990) five approaches to the incorporation of science and technology 4. Curriculum theory (curriculum design, development and evaluation)
Setting	Four secondary schools in Lesotho
Selection of sites and informants	Purposive sampling
Data collection methods	Interviews, observations, achievement tests and document analysis
Analysis of data	Constant comparative method on qualitative data and statistical methods on quantitative data
Reliability and validity	Triangulation, prolonged stay at the site, data collected from a number of sites, tape recording of data collected through interviews and observations
Ethical issues	Informed consent

4.3 Selection of sites and informants

For every study there are many places that could serve as sites, many people who can be interviewed and many documents that can be analysed. But there comes a time when the researcher will need to make a choice of where to observe, who to interview and which documents to analyse (Merriam, 1998). Furthermore, in qualitative research the researcher cannot observe everything, but instead will sample observations that are believed to be representative of everything that they could observe. The sample is supposed to exploit the competing views as well as new perspectives as much as possible (Ary *et al*, 2002).

4.3.1 Selection of sites

The four schools which were chosen as study sites were selected using purposive sampling. The choice was based on the schools' historical performance in junior science examinations, proprietor and the distance of the school from the researcher's workplace. The report on the

performance of these schools was obtained from the records of the Examinations Council of Lesotho. These were the records of performance since 2002, which is the time when all secondary schools in Lesotho undertook the new science syllabus examinations. A school was selected as a case or sample if it had an average pass rate of more than 35% across the grades A, B, C, and D. The four schools had to be from different proprietors. As indicated in Chapter One, the schools in Lesotho are owned by different churches and the government. As such they belong to different proprietors. The pseudonyms of the schools that were selected as site schools for the study were: Jake High School, Metheleng High School, Sofy High School and Lelimo High School.

The researcher acknowledges that the distance from the researcher's workplace to the schools is not one of the most important criteria for selecting the sites. However, the distance from the researcher's workplace to the schools was an important factor, since the researcher was engaged in her normal duties at work during the time of the study. The schools selected had to be close to the researcher's workplace.

4.3.2 Selection of the Form A streams

In each school selected there was more than one Form A stream. Only one stream per school was observed. The streams that were observed were selected purposefully (Merriam, 1998). The factors that were used for the selection were the timetable of the school and the researcher's overall work schedule. The timetables were used in order to avoid clashes between the streams which were to be observed. It was also important that the time between every observation was such that it would allow the researcher enough time to get to the next school.

4.3.3 Selection of Heads of departments and science teachers

Four heads of science departments from the four selected schools were interviewed in the study. Each school had only one head of science department, which automatically made the heads of departments the key informants. Four science teachers, one from each of the participating schools also took part in the study. The teachers that were selected were teaching the classes that were to be observed. Teachers and learners were observed during lessons and as such these learners participated in the study.

4.3.4 Choice of the subject and topic observed

It was not possible to observe all the lessons and the boundary for the observations had to be decided. Only lessons on three physics topics were observed. These were lessons on electricity, waves and pressure. Only physics topics were selected because physics was the area of specialisation of the researcher. She could therefore follow physics lessons with confidence in her area of specialisation. Electricity had been included in the past science syllabi at this level (junior secondary). Waves and pressure were treated for the first time at junior secondary level in the new science syllabus and this gave some variation in the observations.

4.3.5 Selection of other informants

Five curriculum developers who developed the new science syllabus participated in the study as interviewees. Those that were selected had a background in physics or technology. The experts that were interviewed included: a secondary school teacher, the Head of Renewable Energy, Energy Officer, Science Curriculum Developer, and the Director School of Technology. The bias in the selection was based on the fact that the study focused only on physics topics. The researcher believed that the physics or technology experts could give relevant information in relation to the integration of science and technology into the chosen topics.

Two teacher educators, one from the science department of the National University of Lesotho and the other from the Lesotho College of Education were interviewed in the study. Both teacher educators were teaching science education methods or physics education.

The science inspector participated in the study. One of the duties of science inspectors is to support in-service training of science teachers. The researcher felt she could provide information related to implementation of the new science syllabus. As the study progressed it became evident that there was a need to interview the science resource persons in four districts. These were the only science resource persons in Lesotho. The resource persons also provided in-service training for science teachers. Three resource persons were available during the time of the interviews hence only three of them were interviewed. One of the science resource persons worked directly with the schools in the study. It was not anticipated at the beginning of the study that all the mentioned participants would be used as informants. However, as the study progressed the need to include more informants arose.

4.3.6 Selection of documents

The documents which were selected were those that could depict the intended science curriculum. These were the Form A Lesotho Science Syllabus-2002 and the Form A science textbook as well as the 2003 and 2004 JC science examinations question papers. The examination questions papers were those which were available on the new science syllabus during the time of the study.

4.4 Research setting

The research took place in four secondary schools. The four secondary schools were Jake High school, Sofy High school, Lelimo High school and Metheleng High school. The names which were given to the schools are fictitious. All these schools are within the vicinity of the capital town Maseru, although they are from the two districts which are Maseru and Berea. All the schools had a principal, a deputy principal and a head of science department and a laboratory technician. Each school had at least one laboratory. The laboratories were similar. A detailed description of the schools is dealt with in Chapter Five, Section 2.

4.5 Instruments

The instruments that were used in the study are the interview schedules; achievement tests; the syllabus analysis schedule (SAS); textbook analysis schedule (TAS) and observations guidelines. The interview schedules were for the Form A science teachers, heads of science departments, teacher educators, curriculum developers, science inspector and the district science resource persons. All the instruments used in the study are found in the appendixes. The researcher developed all the instruments. The achievement tests, observation schedule, teacher interview schedule and the head of science department interview schedule were piloted at the pilot school. The other interview schedules were piloted with people who had similar background as the group which was going to be interviewed in the study.

4.5.1 Teacher interview schedule

This schedule consisted of semi-structured interview questions. The questions consisted of general questions on the teachers' background. The preliminary data analysis suggested some more areas that needed to be investigated. Probing questions were added as the interviews progressed. Questions focused on the teachers' perceptions of the syllabus, the challenges

they faced in implementing the syllabus, the strengths of the syllabus and their perceptions of their learners' ability to handle the syllabus. All the interview schedules are found in Appendix 4.

4.5.2 Head of Department interview schedule

The heads of departments were interviewed using the semi-structured interview schedule. The questions focused on investigating the function of the Head of Department. They also investigated their perceptions of the new science syllabus, the running of the department, their perception of the ability of their department teachers' to handle the syllabus, and problems encountered by the department in implementing the new syllabus.

4.5.3 Teacher educator

Six teacher educators were interviewed during the study. They were: a lecturer in the department of science education of the National University of Lesotho, a science education lecturer from the Lesotho College of Education; the science inspector, and three district resource persons. Their interview schedule consisted of open ended questions. The schedule focused on their knowledge and perceptions of the new syllabus. The schedule further tried to establish if there was any pre-service or in-service teacher education support to help teachers deal with the new syllabus. It was assumed that there had been some attempts to help teachers deal with the new syllabus. Hence some questions investigated the strategies that teacher educators used in preparing teachers for the implementation of the new syllabus.

4.5.4 Curriculum developers' interview schedule

The interview schedule for curriculum developers consisted of open-ended questions. The questions on the interview schedule focused on investigating the following: the reasons for integrating technology into the science syllabus, the aim of the syllabus, the expected teacher qualification; expected teaching and learning environment, the expected learners' background as well as the expected outcomes of the syllabus.

4.5.5 Syllabus analysis schedule (SAS)

The SAS was constructed based on Gardner's (1990) approaches of incorporating science and technology. It was designed in such a way that it allowed the researcher to classify the different syllabus components/parts according to the different science and technology approaches suggested by Gardner (1990). These are technology-as-an-artifact, technology-

as-an-illustration, cognitive-motivational-approach, science, technology and society and technology-as-a-process. Gardner's (1990) approaches did not cater for instances where science was taught on its own. Hence a fifth category which was used to classify the component of the syllabus that dealt with science on its own was included. The schedule was put on trial on the old syllabus. The researcher used the SAS on the old syllabus with a colleague at work. They compared their results and where there were disagreements they discussed. These improved the validity of interpretation of the schedule. It was finally used on the syllabus under investigation. The different sections of the syllabus were studied in order to establish the approach for incorporating science and technology they focused on. For example the syllabus objective which read "Be able to produce an item from an original design (blue print) (Ministry of Education and Manpower Development, 2002: 7)." was classified as depicting technology-as-a-process approach. But the syllabus objective which read "Be able to identify and interpret the influence of technology on socio-economic aspects of life (Ministry of Education and Manpower Development, 2002: 7)" was classified as an objective which encourages the STS approach. The SAS allowed the researcher to establish the frequency of the different approaches mentioned earlier. The SAS is found in Appendix 2.

4.5.6 Achievement test

The effectiveness of the technology-science curriculum emphasis was investigated using the achievement tests on the topics of focus. These were three sets of tests addressing the topics pressure, electricity and waves. The exercise of developing the tests began with developing the test specifications, which was based on the syllabus objectives. This was done in order to achieve the content validity of the test. The team of experts moderated both the specification table and the tests. The team consisted of the researcher, the science inspector, the JC science examiner who was also a practising teacher, and the science resource person. Based on their comments the tests and the specification table were modified although there was not much change on the specifications. The items on the tests and the specifications were moderated to further improve on the content validity and the face validity of the tests. The tests were further modified based on the results of the pilot study. They were administered to learners after the completion of every topic. The researcher, in collaboration with teachers, developed the marking scheme for the tests. It was however discussed with teachers. The teacher and the researcher marked about five scripts together to agree on marking points. Teachers in some case schools preferred to mark the tests for use in their school records and this was

allowed. However, the researcher marked the test as well after the teacher marked it. Where the researcher marked with teachers the marks were compared and a consensus reached. The achievement tests are found in Appendix 1.

4.5.7 *The textbook analysis schedule (TAS)*

The TAS was developed based on Gardner's (1990) five approaches to the incorporation of science and technology, which are technology-as-an-illustration, technology-as-an-artefact, technology-as-a-process, cognitive-motivational-approach and STS. The TAS was used for classifying the different sections of the book into Gardner's (1990) approaches. After the schedule was developed the science inspector was asked to use the schedule on certain sections of the textbook in order to establish the efficiency of the schedule. The researcher also classified similar areas of the book. The results obtained by the science inspector were compared with those of the researcher. Where there were disagreements they discussed to reach a consensus. This improved the reliability of interpretation of the different textbook sections. The Form A textbook was divided into chapters and sections. The titles of the chapters of the textbook did not correspond with the syllabus topics, although some topics had the same names in both the textbook and the syllabus. Each section of the chapter that was studied was looked at individually. The sections of the book were read and classified according to Gardner's (1990) approaches as indicated. The result was a frequency table for the different approaches used in incorporating technology. For example, the section of the book which started with the example of a technological artefact and then continued with science content was classified as a section encouraging a cognitive-motivational-approach. The section which introduced learners to content and then gave examples of a technological application of that content was taken to be in line with a technology-as-an-illustration approach. A detailed description of Gardner's (1990) approaches is found in Chapter Three. These approaches are further explained on the TAS as shown in Appendix 3.

4.6 Procedure

4.6.1 *The curriculum developers' interviews*

The development of instruments was completed towards the end of 2003. The pilot could not proceed until the following year since it was at the end of the year and schools were about to close for the Christmas break. Instead of waiting for the following year the researcher

interviewed the curriculum developers. Based on the comments of one curriculum developer the interview schedule was modified and administered to curriculum developers in November 2003. Five curriculum developers were interviewed, namely a secondary school teacher, the Head of Renewable Energy, Energy Officer, Science Curriculum Developer, and the Director School of Technology.

The curriculum developers were interviewed individually in their respective offices. Each curriculum developer was interviewed for about 30 to 35 minutes. The interviews were not tape-recorded. The researcher took notes as she interviewed them, later she wrote their views and gave the written statements back to them to review. In their responses they wrote elaborately on points that they thought were not well presented. It is acknowledged that low inference descriptors were not used by not recording the curriculum developers' precise words (Macmillan and Schumacher, 2001). However, by taking their statements back to them the issue of reliability was being addressed through participant review (Merriam, 1998).

The curriculum developers' interviews were followed by the school pilot study which took place between January and March, 2004. The pilot was done in one school in Maseru. Classroom observations for the actual study commenced in April 2004 and continued up to December 2004. The classroom observations were conducted in four schools selected. Four schools provided data from different sources. This according to Merriam (1998) enhances the validity of the research findings.

4.6.2 Pilot study

Setting

The pilot study was done in January-March, 2004. It was carried out in one school in the Maseru district as indicated. The achievement tests, the teacher interview schedule, the Head of Department interview schedule, and the observation schedule were all piloted at this school. The Form A science teacher was a teacher on teaching practice. He taught science to all the three Form A streams. He was registered at the Lesotho College of Education for a Diploma in Science Education.

The school where the pilot study took place was regarded as an average performing school. This is in accordance with the performance of the school in Junior Certificate examinations. The school had one laboratory. The Form A learners could use the laboratory when it was available. In most cases it was reserved for senior students. As a result most lessons took

place in the classroom. The classroom had desks accommodating three students. The laboratory looked very similar to other laboratories in Lesotho. It had gas taps, a fume cupboard, electricity outlets and a water supply system.

The school had the head of the science department who had a Bachelor of Science Education degree. There was no laboratory technician. The Head of Department was very supportive to the practising teacher although the teacher was left to teach on his own.

Classroom observations

The original plan was to use the observation schedule which was developed by the researcher. According to this schedule, the researcher was supposed to classify the interaction which took place in the classroom while observing the lesson. When piloting the schedule it became obvious that this schedule was difficult to use. The task of observing and recording became overwhelming. In the absence of a video recorder which could allow the researcher to transcribe later, this approach was found difficult. The researcher decided to abandon the schedule although the ideas related to it were not discarded. She decided to do whole lesson observations, taking observer's comments and tape-recording the lessons. The tape-recorded lessons were later transcribed. The tapes were transcribed after every lesson except when it was difficult due to the researcher's job commitments. Tape recording and transcribing the data made it easier for the researcher to concentrate on analysing the data later on. In this regard, the pilot helped in improving the approach to the observations. It further provided initial classification of data. The pilot furnished the actual study with the following names of categories: school environment, classroom environment, teacher background, practical work, use of the textbook, and assessment strategies.

Achievement tests

It had been arranged with the pilot school that the three topics of interest be taught early in the year following each other. The achievement tests were administered to the learners at the end of each topic. The tests which were piloted were based on the specification in Table 3. The test table of specification shows the estimated marks per topic and cognitive level.

Table 3 The initial table of specification of the tests: estimated number of marks per topics and cognitive level

Cognitive level →		Knowledge with understanding		Technological applications and socio-economic problems		Design	
		No. of marks	%	No. of marks	%	No. of marks	%
Topic ↓	Total no. of marks on the tests						
Electricity	20	10	50%	7	35%	3	15%
Waves	20	10	50%	7	35%	3	15%
Pressure	20	10	50%	7	35%	3	15%

It was found that the performance of learners was very low and there were some questions which learners could not answer. The researcher decided to have a meeting with the science department to discuss the tests. This could not be done only with the Form A science teacher because he was a practicing teacher and lacked experience. Based on the comments of the science department teachers, the tests were modified. According to teachers the major problem with the tests was that they dealt with some areas of emphasises that the learners were not familiar with. For example, the test included questions on social issues related to science that learners were supposed to have studied. These were questions which were trying to relate to the STS approach. Learners also found the questions which related to design, difficult. Teachers indicated that they had not touched these areas in their teaching. The following is one of the comments made by one teacher during the meeting.

Question C (ii) Learners knew nothing about the buzzer since they were concentrating on bulbs, cells and 3-pin plug. Also the designing part was very tricky since the syllabus says nothing about designing but it looks at assembling especially simple circuits.

One of the objectives of the Lesotho science syllabus requires that learners should “be able to produce an item from an original design (blue print) (Ministry of Education

and Manpower Development, 2002: 7).” This objective can be assumed to imply that learners should design items and produce them. However, teachers did not seem to have addressed this area. As a result this area was not included in the final test table of specification. Furthermore teachers perceived technology as the context upon which they could apply science.

Another problem was related to scope of content, especially content related technological artifacts. The learning outcomes dictated the artifacts that should be dealt with in the classroom but failed to show depth. For example, this is what one of the teachers said in relation to one of the questions in the test.

The syllabus seems to be very shallow looking at the first question 1. (a) i, which says describe how the above battery works to produce electricity. In the syllabus, the objectives, content and review do not say anything about this.

Teachers assumed that they only had to indicate that the battery is a source of electrical energy. They did not get into the details of how the battery works. The important point to note is that teachers did not seem to consider the broad objectives of the syllabus. They concentrate on the learning outcomes although they refer to them as objectives and the content. Based on these comments the tests were modified. The effect of the modifications on the test specification was that the items testing the areas of emphasis such as STS and design were replaced by application of science in everyday life. The final table of specification is as shown on Table 4

Table 4 The final table of specifications of the tests: estimated number of marks per topics and cognitive level.

cognitive level →		Knowledge with understanding		Application of science in everyday life	
		Total no. of marks	No. of Marks	Percentage marks	No. of marks
Content ↓					
Waves	20	12	60%	8	40%
Pressure	20	12	60%	8	40%
Electricity	20	12	60%	8	40%

4.6.3 Interview schedules

The interview schedules that were put to trial in this school were the head of science department interview and the science teacher interview. The interview questions were mainly modified to achieve more clarity. However, the Form A science teacher at this school was a student teacher and one could not get much from him due to lack of experience. Other interview instruments were tried on individuals that were not found in this school. For example, the trial for the curriculum developers' interview schedule was done on one teacher who is a panel member but who did not participate in the actual study. The science inspector interview schedule was piloted with the mathematics inspector. The mathematics inspector used for piloting had a background in science. She had taught science in secondary schools before she became an inspector.

4.6.4 The school observations

The pattern that the observations took was influenced by the situation in the schools and the experience gathered during the pilot study and the initial phase of the study. The schools closed between May and August and hence observations ceased during this period. At the beginning of the classroom observations it was not easy to make observations in four schools at the same time. This was due to time pressure and lack of experience. Furthermore the observations time at the schools depended on whether the teacher was teaching the topic of interest or not. As such the time for observing at a school was influenced by the teachers' year plans. Due to circumstances such as those mentioned the observations were finally conducted in stages. The first stage was before the schools closed for winter break (April to May). The second stage was between August and October. In October the schools closed for independence holidays. After independence the observations continued until end of November when the schools closed for Christmas holidays. During the first stage of observations data were collected from two schools. The observations were tape-recorded and later transcribed. The transcription took place after every observation. Field notes were also written during observations. These notes helped during the transcriptions of the tape-recorded observations since they highlighted the most important aspects of the lessons. Furthermore a summary and impressions about every lesson were made after every observation. These were later expanded into memos after transcribing tapes (Strauss & Corbin, 1998).

Preliminary analysis was done on the data after the first phase of observations. That is between May and August 2004 while the schools were closed for winter holidays. This analysis guided the researcher in forming some initial hypotheses, which were used to guide the data collection during the second phase. Two teachers and two heads of science departments were interviewed during this phase. The heads of departments and the teachers were from the schools that were observed.

The second stage of observations started in August 2004 and ended in October 2004 as indicated. The observations for this phase were done in all four schools. The researcher had gained experience in carrying out the observations and the teachers' timetables permitted this. Data collected during this period was still used to inform the third observation period.

Additional heads of science departments and two other teachers from the additional schools were interviewed during this phase. The interviews were still based on the original interview questions but some questions were added which allowed the researcher to probe deeper into the problems of the study. The preliminary analysis had made the researcher aware of more questions that needed answers. She therefore included these questions during the second stage of interviews. Data analysis continued. More questions which needed to be addressed by the study surfaced and were integrated into observations and interviews.

The third period of observations included the four schools. The observations started in October 2004 and ended in November 2004. The independence holidays were only one week long. They did not allow much time for analysis of data. Teachers were under pressure to prepare for the end of year examinations during the period between October and December. They arranged extra lessons. This significantly increased the workload of the researcher and it became almost impossible to transcribe tapes after every lesson.

At the end of every topic the learners were given an achievement test. The test was on the topic that had just been taught. The tests were prepared before observations. The tests were based mainly on the syllabus and the teachers' comments made during the pilot study. The researcher had prepared the marking memorandum for each test. Teacher educators and the science inspectors were interviewed in May 2005 while the science resource persons were interviewed in June 2005.

4.7 Issues of reliability and validity

According to Merriam (1998), all research is concerned with producing valid and reliable information in an ethical manner. The trustworthiness of the research results depends on the extent to which validity and reliability have been accounted for in the study. Ary *et al.* (2002) asserted that the terms validity and reliability are commonly associated with quantitative research. However, making valid inferences from data and having consistent data which are issues of validity and reliability are as important in qualitative research as they are in quantitative research. The literature suggests many ways of enhancing validity of the qualitative research study. Merriam (1998) suggests the following: triangulation, member checks, and long-term observations, peer examination, participatory or collaborative modes of research and researchers' bias. Macmillan & Schumacher (2001:408) summarised strategies that enhance design validity as in Table 5:

Table 5 Strategies used in the study to enhance validity

Strategy	Description
Prolonged and persistent field work	Allows interim data analysis and corroboration to ensure the match between findings and participant reality
Multi-method strategy	Allows triangulation in data collection and data analysis
Participant language ; verbatim accounts	Obtain literal statements from participants and quotations from documents
Low inference descriptors	Records precise, almost literal, and detailed description of people and situations
Multiple researchers	Agreement on descriptive data collection by the research team
Mechanically recorded data	Use of tape recorders, photographs, and video tapes
Participant researcher	Use of participants recorded perception in diaries or anecdotal records for collaboration
Member checking	Check informally with participants for accuracy during data collection; frequently done in participant observation studies.
Participant review	Ask each participant to review researcher's synthesis of all interviews with the person for accuracy of representation; frequently done with interview studies
Negative cases or discrepant data	Actively search for, record, analyse, and report negative cases or discrepant data that are an exception to patterns or that modify patterns found in the data.

The most common method for enhancing validity is the triangulation method. Krathwohl (1998:276) defined triangulation

as a process of using more than one source to confirm information: confirming data from different sources, confirming observations from different observers, and confirming information with different data collection methods. With the discovery of disconfirming information, seeking reasons for contradiction frequently points to the direction for extending or modifying explanations instead of discarding them.

Krathwohl (1998) indicated that there are three types of triangulation which are: (i) data triangulation which involves using multiple sources of data, (ii) investigator triangulation which involves multiple investigators, (iii) method triangulation which uses multiple sources of methods of collecting data. Merriam (1998) also alludes to these types of triangulation and still explains them in a similar manner.

As indicated in Section 4.6.4, the observations started in March 2004 and ended in November 2004. This was a long enough time to allow the teachers and the researcher to get used to each other and to be comfortable with being observed. In addition, this length of time in the field allowed the researcher to do preliminary data analysis, which informed the collection of data that was done later.

The data, which were collected during classroom observations, were tape-recorded. The data were later transcribed. The use of a tape recorder allowed the researcher time to transcribe the data and to capture the words of the participants as they said them during the observations and interviews in the best possible way. These accounts are very important as researchers use them as quotations from data to illustrate participants' meanings (Macmillan & Schumacher, 2001). Macmillan and Schumacher further indicate that the low inference descriptors, which are concrete and precise data, are hallmarks of qualitative research and guide in establishing patterns. The same authors define low inference descriptors as descriptors, which are almost literal, and that the words used are those used and understood by participants.

Most of the interview transcriptions were given back to participants who were interviewed in order to allow them to check if the transcripts represented what they were saying during the interviews. Member check is another method, which is suggested in the literature as a way of enhancing validity. Merriam (1998) said member checking involves taking data back to the participants and asking them if the results are plausible. In this study this has been done with most of the participants.

As indicated in Section 4.3.1, the observations in this study were done in four case schools. There are two hundred and ten secondary schools in Lesotho. The researcher could not include schools in the remote areas of Lesotho in the study. This was due to time limitations. The four schools selected however provided multiple sources of data as a single source can

not be trusted to give a comprehensive interpretation (Merriam, 1998). In addition the data were collected using different strategies. For instance, the study used document analysis, interviews, classroom observations, and tests. Macmillan & Schumacher (2001) allude to the fact that most qualitative research depends on multiple strategies for collecting data.

4.8 Data analysis

Once the data have been collected, the researcher is faced with massive data that he or she has to make meaning out of. This process involves consolidating, reducing, and interpreting data with the aim of making meaning. The process further involves moving back and forth between concrete and abstract concepts, between induction and deduction reasoning, between describing and interpreting (Merriam, 1998).

As indicated in the introduction to this chapter, this study investigated the nature of the planned and the experienced curriculum. The planned curriculum was mainly investigated through documents analysis and the experienced curriculum was examined through classroom observations and interviews. The analysis of data therefore involved analysis of documents, classroom observations and interviews.

The documents that were analysed were the science-technology syllabus, the textbook and the Junior Certificate Examination (JC) science question papers. The detailed description of how the syllabus and the textbook were analysed is found in Sections 4.5.5 and Section 4.5.7 respectively. Data obtained from JC examination science question papers, interviews and classroom observations were analysed qualitatively.

As indicated in Chapter Three, the approach which was used for analysing qualitative data in this study is the constant comparative method. Data analysis began during the data collection period. The researcher made impressions on interviews and observations and began writing the observer's comments and memos at the initial stage of data collection (Strauss & Corbin, 1998). Macmillan & Schumacher (2001) agree with this approach as they said data analysis begins at the initial stage of data collection in qualitative research and continues parallel with data collection.

After the first stage of data collection the researcher began open coding both the interviews and the observations. That is assigning preliminary codes to the initial interviews and classroom observation data. Initial codes were mainly derived from the data but some codes were from the literature. Other codes were based on the researcher's experience. These

codes were then classified into subcategories. The subcategories were then classified into categories or themes. The subcategories were found to be in line with the classification suggested by Stake (1967). The researcher therefore decided that the antecedents, transactions and outcomes would be the themes. This process led to classification of the subcategories into antecedents, transactions and outcomes. This allowed the researcher to investigate the contingency between the observed antecedents, the transactions and the outcomes. It further made it possible to examine the congruency between the planned and the observed antecedents, transactions and outcomes. In this way the researcher compared the planned curriculum and the implemented curriculum. In this process Stake's model was used as a guide in the analysis of data. However the process allowed subcategories to emerge from the data.

As indicated in Chapter Three, in using Stake's model the congruency between the intended curriculum and the implemented curriculum is investigated at three levels. These are at the level of the antecedents, transactions and outcomes. In the case of the intended curriculum the mismatch between the curriculum materials was taken as the antecedent. The proposed STS approach was classified as the planned instruction, hence intended transaction. The goal for the science-technology curriculum which was to achieve scientific literacy was taken to be the planned outcome. In a similar manner, in investigating the implemented curriculum teachers' perception of the science-technology curriculum was classified as the observed antecedent. The way teachers taught the science-technology curriculum was taken to be the observed transaction.

Data from the different sub-cases were analysed individually in order to get a comprehensive interpretation of the case. The researcher then looked for the subcategories which cut across the cases. However, the categories peculiar to a case were still taken on board if they strongly suggested something in the interpretation of data. Comparing and contrasting between cases, identifying key categories, and asking about the differences and the similarities between the sub-cases moved the analysis of data in this study to the level of axial coding.

4.9 Ethical considerations

According to Macmillan & Schumacher (2001), ethics in research studies involve considerations of informed consent, deception, confidentiality, anonymity, privacy and harm to the subjects. In this study an attempt has been made to consider some of these ethical issues.

Before the observations started at the schools the researcher approached the principals of the schools. The principals were informed of the study and its purpose as well as the intention to conduct the study at their school. Each of the principals was given the research proposal. After they had agreed, the principals arranged a meeting with heads of departments who were also informed of the purpose of the study and discussed the issues surrounding the research. Together with the Head of Department the researcher arranged the classes that could be observed. These meetings led to the meetings that the researcher had with the teachers who were to be observed. The teachers were asked if they agreed to participate in the study. They were also informed of their right to withdraw from the study at any time. Teachers were assured of the confidentiality of the information gathered from the observations and interviews where applicable. The researcher indicated to them that they would be given access to transcripts which concerned them, for approval. The researcher gained the permission of teachers to tape record their lessons. Furthermore the names of the participating schools and persons have been replaced with pseudonyms.

Before the observations could start the teachers informed the learners about the presence of the researcher in the school and the reasons for her being in their classrooms. The learners were also asked permission to allow the researcher to observe in class as well as use their test results for the study. The tests that learners wrote during the study were always marked and returned to learners. They were then asked if the researcher could use them in the study. In all cases learners agreed.

The other educators who participated in the study like the curriculum developers, and teacher educators were also informed of the study. Similar ethical considerations as those provided to the teacher were also discussed with them.

The names of individuals who participated in the study have not been used in any way. The data have not been related directly to any of the persons involved in the study in a direct manner.

4.10 Limitations of the research

As indicated in this Chapter, the observations that were made at the schools depended on the teachers' plans. As a result, some topics were not observed in all case schools. This is a limitation since the original plan was to observe all the topics in all case schools. However, it

was not possible to rearrange the teachers' schedules. That would be interfering with the setting.

The schools that were selected were those that the researcher could easily reach. This did not allow the school far from the capital city to be observed. It could have been interesting to find out how the science-technology curriculum was implemented in the most remote areas of Lesotho. When four teachers were observed in the study, they may not reflect the diversity in teachers' educational background that exists in Lesotho. There are probably more teachers who are not qualified who teach in schools which are less resourced than the schools which were observed. Furthermore, it is possible that there are learners in the remote areas of Lesotho who are not familiar with most of the technological artefacts which are presented in the syllabus. These are the areas that the study could not cover due the circumstances that have already been highlighted in the methodology section.

The end of year examinations had put much pressure on teachers. In most cases teachers had to plan extra lessons so that they could cover the topics that were to be observed. The extra lessons increased the researcher's workload because the number of lessons observed per day had increased. As a result, the researcher could not transcribe all the lessons after every observation. Transcribing observation data before observing the next lesson always informed the next observations. This style of working could not be maintained under the circumstances.

In one of the case schools the teacher often missed classes. There was nothing special about his absenteeism, except that this was reported to be his normal behaviour by the Head of Department. He arranged extra lessons so that he could be observed. This also interfered with the planned schedule and supposedly disturbed learners.

It was observed that the learners did not experience the same curriculum, especially in regard to the treatment of technological application. However, the achievement tests, which had included detailed treatment of technological artefacts, were still administered to learners. This was unfair to learners, as their experiences with regard to treatment of technological artefacts were different.

4.11 Summary

Summary of research questions and research procedures that are used in the study is as in Table 6.

Table 6 The summary of research questions and procedures used in the study.

Research questions	Type of data collected	Data collection strategy	From who/what data was collected from	Validity and reliability	Data analysis
What is the nature of the new Lesotho junior science-technology curriculum?	Qualitative and quantitative	Interviews Observations Document analysis	Curriculum developers Classroom Teachers Heads of departments Syllabus	Triangulation Prolonged stay at the sites Tape recording	Constant comparative method and statistical methods
How is the new science-technology curriculum implemented in the classroom	Qualitative and quantitative	Observations Tests Interviews	Teachers Heads of departments Teacher educators Classroom observations Learners performance	Prolonged stay at the site Multiple sites triangulation	Constant comparative method Constant comparative method and statistical methods

Chapter Five describes the results of the study. It outlines the intentions of the Lesotho science curriculum as depicted by the curriculum materials. It further discusses the findings of the study in relation to the implemented curriculum.

5. Results and discussion

5.1 Introduction

This study explored the nature of the Lesotho science-technology curriculum as well as how it was implemented in the four schools involved in this study. Stake's congruency-contingency model was used to guide the collection and analysis of data. The analysis also drew inspiration from other theoretical constructs such as: Gardner's (1990) approaches to the incorporation of science and technology; the constant comparative approach (Merriam, 1998); and some aspects of curriculum theory, particularly curriculum development and curriculum evaluation as espoused in the works of certain scholars (e.g. Ornstein & Hunkins, 2004; Stenhouse, 1988). The curriculum intentions were investigated through the analysis of curriculum materials while the implemented curriculum was investigated by examining the teacher-learner-material interactions.

Stake's model involves two types of data. The first set of data deals with the planned antecedents, transactions and outcomes while the second set of data is concerned with the observed antecedents, transactions and outcomes. According to McCornick & James (1998) and Ornstein & Hunkins (2004) each set of data has to be evaluated for logical contingency in terms of whether or not the intentions are related to the antecedents or are logically coherent with the transactions and outcomes. Furthermore the two sets of data are compared in order to assess congruency between the planned curriculum and the implemented curriculum.

The data for the investigation were collected through document analysis, classroom observations, interviews and achievement tests. A multiple case study design was adapted for this study. It is recognised that curriculum studies are concerned with the relationship between intentions and what really happens in the classroom. Without undermining this understanding the data in this study have been divided into the two sets of data as suggested by Stake's model. For ease of reference, the data analysis has been divided into two sections. Section 1 presents the results and discussions relating to the intended Lesotho science-technology curriculum and section 2 deals with the results and discussions related to the implemented curriculum.

5.2 Section I: The intended curriculum

5.2.1 Introduction

The intentions of the Lesotho science curriculum were examined in terms of the way they have been presented in the science syllabus as well as other curriculum materials such as the and examination papers. It is assumed that the curriculum materials such as the syllabi, textbooks and assessment tools convey explicitly or implicitly the objectives of the curriculum to the curriculum users. Curriculum materials therefore, play an important role in communicating the intended curriculum to those who use it.

Gardner's (1990) model categorises the incorporation of technology into the science curriculum in terms of the following approaches: cognitive-motivational-approach, technology-as-an-artefact, technology-as-a-process, technology-as-an-illustration, science technology and society. These categories were used as a guide in designing the syllabus analysis schedule (SAS) and the textbook analysis schedule (TAS). The SAS and the TAS were used for analysing the syllabus and the textbook respectively. Gardner's (1990) model was further used qualitatively in analysing the Junior Certificate (JC) examination question papers and the interviews conducted with the curriculum developers. Furthermore, aspects of curriculum theory dealing with the curriculum development process were used in explaining some observations relating to the process.

This section outlines the intentions of the Lesotho Junior science technology curriculum (LJSTC) as depicted in the syllabus, the textbook and the examination question papers based on the topics listed in the syllabus. The section highlights, in the form of questions, the issues surrounding curriculum development in Lesotho. Some of these critical questions which warrant closer considerations are: Who designs the LJSTC? How is it developed? Which circumstances determine the incorporation of technology into LJSTC? The assumption here is that an analysis of curriculum materials will illuminate the nature of integration of science and technology in Lesotho secondary schools. The section further discusses the intentions of the curriculum as perceived by science panel members. It is envisaged that examining their perceptions would further clarify the nature of the intended curriculum.

5.2.2 Curriculum materials development

The syllabus

As indicated in Chapter One, the National Curriculum Development Centre (NCDC) is the department of the Ministry of education responsible for curriculum development in Lesotho. It uses the system of subject panels. The NCDC usually suggests the curriculum design model to be adopted in developing the curriculum for different subjects. This model is communicated to the panel by the curriculum expert. The model which is used for different subjects is the same. This suggests that the curriculum design model used in developing the science-technology curriculum was decided by the NCDC and communicated to the panel by the curriculum expert. The NCDC decides on the model in order to achieve uniformity across the different subjects.

In developing the science-technology syllabus the science panel first drafted a mission statement, which reflected the national goals. From the mission statement the panel developed the general objectives or broad statements of intent. This was followed by the development of specific objectives which in turn were meant to guide the selection of content, approaches to the teaching of the syllabus, and the type of assessment of learning outcomes. After developing the specific objectives the panel then chose the content and sequenced it to produce the scope and sequence chart. This chart normally shows how the content flows across the different levels of secondary education. The scope and sequence chart guided the development of the intended learning outcomes (ILOs). Ornstein & Hunkins (1993) defined the ILOs as specific statements of intent which are stated in terms of expected observable behaviour of learners after they have been taught. The process of curriculum development described is summarised as in Figure 4.

As indicated in the previous section, the aim of the common syllabus design was to achieve uniformity across the different subjects. This approach assumes that all subjects can fit in the same curriculum design. Ornstein & Hunkins (2004) suggested that subjects that are integrated tend to adopt the horizontal design. Horizontal designs encourage scope and integrations hence allowing content from different subjects to be brought together. On the other hand vertical designs deal with sequence and continuity. Sequence and continuity involves introducing a concept in one grade and teaching it again in the following grade. The science-technology curriculum attempts to integrate science and technology. To assume that science (biology, physics and chemistry) and technology as integrated subjects would use the same curriculum design as subjects like mathematics might not be realistic. The curriculum

design adopted for the science-technology curriculum seems to fit the vertical design. It can be assumed that the design adapted for the science-technology curriculum would not easily allow content to be drawn from different subjects since individual subjects have different ways of sequencing concepts and establishing continuity.

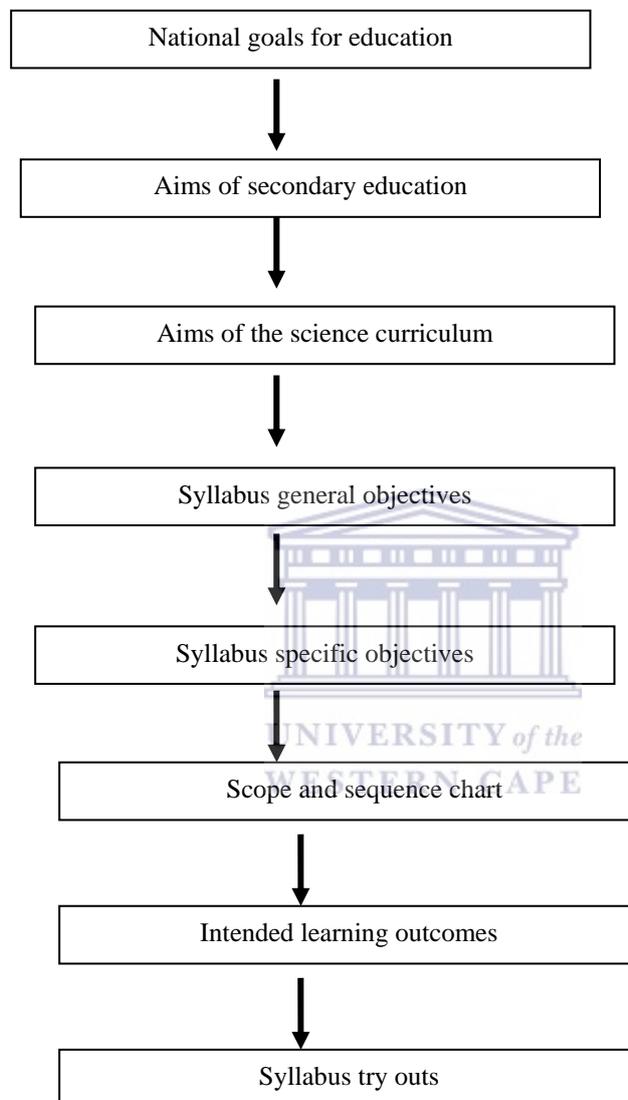


Figure 4 *The stages of curriculum development in the case of Lesotho*

The curriculum development view that is depicted in Figure 4 and the description of the process of curriculum development in Lesotho suggests a technocratic perspective to curriculum development. Firstly, the curriculum developer, who is assumed to be an expert in the curriculum field, guided the science-technology curriculum development. Secondly the process followed a step-by-step procedure. Moreover this process was hierarchical and sequential starting with the aims and flowing to the learning outcomes. Posner (2002) and

Ornstein & Hunkins (2004) argued that an approach to curriculum development that portrays the described characteristics is associated with technical approach. Eisner (2004) and Ornstein & Hunkins (2004) argued that curriculum developers who follow this perspective are inclined to focus more on the process than to rationalise the different components of the process.

Figure 4 further depicts the curriculum development procedure that focuses more on the plan. There is no evidence that an effort was made during the development of the syllabus to link the development with the school context. The trial runs were only done after the plan had been completed. According to Ogunniyi (1996), it is expected that the trial runs would take place during the construction stage. This should have taken place during the development of the scope and sequence chart and the learning outcomes.

In summary, the process of developing the science-technology curriculum in Lesotho seems to suggest that curriculum developers held a technocratic perspective of curriculum design. Furthermore, the design model used might not accommodate integration. Lastly the process focused more on a plan neglecting the school context.

The Textbook

After the syllabus had been developed, relevant textbooks were written. In the case of the science syllabus that this study is evaluating, the textbooks were written mainly by the subject panel. Three textbooks were written. They served as curriculum materials, which illustrated the incorporation of technology into the Lesotho science syllabus. The idea of using textbooks to support curriculum reform is not new to Lesotho. Textbooks were used in Canada in 1986 to support curriculum implementation when the New junior high school science curriculum was implemented (Roberts, 1995). In Lesotho, the Panel members who developed the curriculum were chosen to write the textbooks because they were supposed to be familiar with the content and goals of the curriculum. As a result they were in a better position to align the syllabus with the textbook. However, the panel also sought the assistance of a publisher who in turn brought some expertise into the writing of the textbooks.

Using the panel to write the textbook appears to have been a good idea since it gave the panel members a second chance to present and represent their intentions (Dreyfus, 1992). On the other hand the inclusion of teachers who are not necessarily panel members could have given the teachers an opportunity to critique the science-technology curriculum. In this

arrangement where curriculum developers developed the curriculum and wrote textbooks, the teachers were left to implement the curriculum developers' intentions.

The examinations

As indicated in Chapter One, the Examinations Council of Lesotho (ECoL) develops tests for external examinations at the junior secondary school level. The council uses a system of examiners, where one or two examiners develop items for the test. A team of experts then moderates the test. Under normal circumstances the NCDC subject panels are supposed to decide on the table of specification for the examinations. It is assumed that the panel members are knowledgeable regarding the intentions of the curriculum and therefore are in a better position to guide ECoL in terms of aligning the curriculum with assessment.

According to Lewin (1998), curriculum reform can be reinforced by tests, which reflect the goals of the curriculum. As a result examinations can play an important role in supporting the science education curriculum initiatives. Subsequently, (Lewin & Dunne, 2000) indicated that the need for examinations to support curriculum initiatives has been voiced in many African countries. However, weak links which exist between curriculum and assessment bodies in many African countries have led to the mismatch between curriculum and assessment. In the case of Lesotho the curriculum is developed by the NCDC and examinations by the ECoL. Examiners can only become acquainted with the curriculum goals through reading the syllabus. This suggests a weak link between curriculum and assessment.

5.2.3 The process of incorporating technology

As highlighted in Chapter One, the inclusion of technology into the school curriculum in Lesotho was seen as a strategy for achieving scientific and technological literacy among all Basotho. Scientific and technological literacy was assumed to be a central feature of economic development. On the other hand the inclusion of technology in the school curriculum is in line with global trends in science and technology education (Jenkins, 1996; Yoloye 1998; Sjoberg, 2003; Layton, 1994).

However, there are many perspectives to technology education. Furthermore there are many stakeholders in technology education who hold different opinions regarding the inclusion of technology in the school curriculum (Layton, 1994). The inclusion of technology in the Lesotho curriculum was therefore faced with these challenges. The panel had to deal with

these challenges. As a result attempts were made to support the panel in its endeavours. In an attempt to integrate technology into the school science curriculum and to understand what constitutes such integration, the science panel invited resource persons from the Department of Technology, Department of Mining and Geology, Technical School of Lesotho, and Department of Appropriate Technology. These resource people came into the panel with different backgrounds of technology education. They therefore brought different perspectives of technology education into the panel meetings. The science panel further undertook a study tour of South Africa with the aim of investigating how other countries had dealt with the issue of technology and to understand what the inclusion of technology encompassed. At the time of the study tour to South Africa, it was discovered that technology was a stand-alone subject in the curriculum for South Africa. This visit did not help in the case of integration. Despite these activities, the different understandings of the inclusion of technology still surfaced among the panel members. However the panel continued to integrate technology into the science curriculum to the best of its ability and wrote textbooks for the syllabus. The textbooks that were written by the panel were the only exemplary materials for teaching the new science-technology curriculum.

Many competencies are necessary to develop a new curriculum. Since no one person possesses all these competencies, many experts may be brought together to develop curriculum (Lewy, 1977). In that way, inviting technology experts into the science panel was a positive move. As indicated in the previous section, different stakeholders in technology education have varying views about technology education. As a result the technology experts brought different perspectives of technology education into the panel. Consequently, it could be assumed that the science panel developed the science-technology curriculum without common understanding of the integration of science and technology. There is no evidence to suggest that the science panel ended up understanding what inclusion of technology encompass based on the efforts that they undertook.

As a result of recognising the importance of science and technology in economic development and in addressing issues of *Science for All* and scientific literacy, the inclusion of technology in the school curriculum is on the national agendas of many countries (Layton, 1994; Yoloye, 1998; Lewin, 1992). As a result there are many curriculum programmes which have attempted to incorporate science and technology. A literature search in the area of science and technology and specifically the integration of science and technology could have supported the science panel in their efforts to incorporate science and technology. For a

complex curriculum area like technology education they needed more information from diverse sources in order to make informed decisions.

In summary the inclusion of technology into the science curriculum in Lesotho was essentially an effort to address the issues of *Science for All*. Consequently the science panel was following global trends in this area. The science panel made attempts to understand what the incorporation of science and technology entails. However they undertook the process of developing the science-technology curriculum without much understanding of the curriculum area.

5.2.4 The science curriculum intentions

Introduction

As indicated in the introduction section, the syllabus attempts to convey to the teachers and learners the intentions of the curriculum and what will be examined at the end of the particular programme. From my observations prior to this study, both teachers and learners take the syllabus very seriously. In extreme uses the teaching-learning activities revolve around the examination syllabus at the expense of other useful knowledge. Because of the critical position of the syllabus in the curriculum planning-implementation process, this study considered it worthy to analyse the new science-technology curriculum. This was done by developing a Syllabus Analysis Schedule (SAS). The SAS classified sections of the syllabus based on Gardner's (1990) model which suggests five approaches to the incorporation of technology such as: technology-as-an-illustration, technology-as-a process, science-technology-society (STS), technology-as-an-artefact and cognitive-motivational-approach. However in view of other issues not reflected in the model (like science content only), the model was modified to include this issue. Although the main focus of the analysis was to establish the type of science-technology approaches depicted by the syllabus, interesting ideas related to science education that were spotted during the analysis have also been reported.

The structure of the syllabus

The science curriculum is given to schools in the form of a syllabus. It is intended for junior secondary learners who sit for the junior examinations at the end of three years of secondary education. The syllabus is structured such that it consists of the following: The introduction, mission statement, teaching approaches, assessment, suggested equipment, table of general objectives, table of specific objectives, table of learning outcomes, suggested activities, and

the scope and sequence chart. Table 7 shows the different aspects of the syllabus and their specific functions.

Table 7 Different aspects of the syllabus and their specific functions

Part of the syllabus	Its function in the syllabus
The introduction	Describes the syllabus and gives the purpose of the science syllabus.
Mission statement	Outlines what learners should be able to do as a result of going through the syllabus.
Teaching approaches	Suggested teaching approaches for the syllabus.
Assessment	Outlines the assessment strategies
Suggested equipment	Consists of a list of suggested equipment for Form A (grade 8) according to the three science disciplines (chemistry, biology and physics).
Table of general objectives	Outlines the objectives for the syllabus.
Table of specific objectives	The table of specific objectives or the end of course objectives breaks down the general objectives into more specific objectives.
Table of learning outcomes with content and suggested activities	Classifies learning outcomes according to level as well as the discipline and topic.
Scope and sequence chart.	Shows the sequencing of content from Form A (Grade 8) to Form E (grade 12) according to three science disciplines.

Although Table 7 shows the different aspects of the syllabus and their specific functions, it does not show the details of the different parts of the syllabus. The following sections examine the different parts of the syllabus in order to reveal the nature of the intended curriculum as portrayed in the syllabus.

The syllabus introduction

The introduction states that the syllabus consisted of biology, physics and chemistry. It further indicates that issues relating to technology, environment and population as well as family life had been incorporated into the syllabus where appropriate. The introduction also shows that the syllabus is meant for learners for whom Form C (grade 10) is terminal as well as those who would continue with their education. The purpose of the science curriculum as presented in the mission statement in the syllabus is to:

enable learners to acquire knowledge, skills and attitudes in science and technology that would enhance permanent and functional literacy and numeracy for continuous learning and effective participation in social issues and activities (Ministry of Education and Manpower Development, 2002:1).

What seems obvious in the mission statement is the concern that learners should acquire critical, scientific and technological knowledge, skills and attitude that would make them functional members of society. However the preparatory role of science for further learning is not ignored. Curriculum statements such as this one are common in curricula that try to address the issues of scientific and technological literacy for all (for example, Tan (1988) in the case of the Philippines and Nganunu (1988) in the case of Botswana). This mission statement shows an attempt to address some current issues in science and technology curriculum. What is common about these curricula is that they try to address the goal of *Science for All*. They also integrate science subjects, address issues of context, show concern for environmental issues and puts emphasis on technology (Sjoberg, 2003).

Teaching approaches

As shown in Table 7 the science syllabus also suggested teaching approaches. The teaching approaches suggested by the science syllabus encourage learner-centred approaches such as practical work through experiments, inquiry through investigation and projects involving analysis, and design of articles or items (Ministry of Education and Manpower Development, 2002). Of interest among the approaches that have been suggested is the “designing of articles or items”. According to the literature design is central to technology education (De Vries, 1994; Gardner, 1999). When included among the teaching approaches for teaching science integrated with technology, this element suggests technology-as-a-process-approach (Gardner, 1990); this emphasises the development of technological capabilities. The science content in this case is used as a resource for enhancing problem solving, which includes inventing and designing (Layton, 1993). Based on this discussion the Lesotho science-technology syllabus through the teaching approaches adopted the usual science teaching approaches and technology-as-a-process approach.

The assessment strategies

The assessment strategies suggested for the end of each grade at secondary level and Junior Certificate (JC) examination are paper and pencil tests and continuous assessment on project work. Project work that is encouraged includes surveys, design and production of articles and items. As indicated in the previous section the issue of design and production of items is in line with technology-as-a-process approach. The design aspect would need more specialised equipment. Furthermore, this curriculum was supposed to be taught by science teachers and they do not have expertise in areas

such as design. The approach for integrating science and technology using technology-as-a-process was an ambitious intention, given that many schools in Lesotho do not have basic science equipment.

The list of suggested equipment

The list of equipment as indicated in Table 7 consists of a list of suggested equipment for Form A (grade 8) which is arranged according to the three science disciplines (chemistry, biology and physics). The list of equipment for Form B (grade 9) and Form C (grade 10) is not included in the syllabus. Taking Form A physics as an example, all the equipment in physics include the usual physics equipment, except the equipment which is suggested under the topic “machines” where there are some unusual equipment such as: an axe, chisel, levers, hammer, gear box, steam engine, sewing machine, and mechano kit. In physics this type of equipment can be used to illustrate types of machines. It does not necessarily relate to technology. As such the list of suggested equipment basically consists of the usual science equipment. Design by its nature includes a drawing element and there is special equipment for drawing. Production of items, no matter how small the items could be, would still require specialised equipment such as materials to be used, cutting equipment and many more. It would be very difficult for schools to acquire these pieces of equipment. From the researcher’s experience working with many schools it had been observed that schools in Lesotho already have a shortage of basic laboratory equipment and as indicated in Chapter One the education system is under pressure due to expanding educational needs.

The general objectives and the specific objectives

The syllabus consisted of seventeen general objectives. Analysis of these general objectives revealed that twelve were related to technology inclusion. Four related to environmental education and one was associated with population and family life. Table 8 shows this classification with illustrative examples. The analysis of the general objectives shows that the inclusion of technology into school science was intended to be the major area of emphasis.

Table 8 Classifications of the syllabus general objectives according to three areas of emphasis

General objectives	No. of objectives	Example from the syllabus of the general objectives as classified
Related to technology inclusion	12	Have developed awareness and appreciation of the scientific and technological activities, and interdependence of scientific, socio-economic and technological changes in Lesotho and other countries” (Ministry of Education and Manpower Development, 2002: 5)
Related to environment education	4	Have developed scientific knowledge and skills to interact with the environment appropriately (Ministry of Education and Manpower Development, (2002: 5).
Related to population and family life issues	1	Have acquired scientific knowledge, and skills for population management and its implications for the environment

The study focuses on technology inclusion. The objectives which related to environment and those associated with population and family life were not considered for further analysis. The objectives that were further analysed were those relating to technology. The analysis of general objectives related to technology inclusion using the SAS suggests that most of the objectives encouraged science, technology and society (STS) approach. The results are shown in Table 9.

According to Gardner (1999) STS approach places less emphasis on technological capabilities and science content and places more emphasis on the problematic nature of scientific knowledge. The aim of STS according to Layton (1993) is to contribute to technology education through technological awareness.

Earlier in this section, it was indicated that the approaches suggested for teaching the new science-technology syllabus designing and producing items. The assessment strategies also suggested project work which involves designing and producing articles or items.

Formulating design and producing items are technological capabilities associated mostly with technology-as-a-process approach. On the other hand, the general objectives suggest an STS approach.

Table 9 Science and technology approaches as depicted by the science syllabus general objectives

Technology approach	No. of general objectives	Examples
Technology-as-an-illustration	0	-
Cognitive-motivational approach	0	-
Technology-as-an-artefact	0	-
Technology-as-a-process	2	Have developed confidence, responsibility and ability to apply scientific method in developing new ideas, solving problems, designing and producing materials for self directed learning in all situations. (Ministry of Education and Manpower Development, (2002: 6).
Science, technology and society	10	Have acquired scientific knowledge, skills and attitudes to solve problems related to socio-economic and technological changes. (Ministry of Education and Manpower Development, (2002: 5).
Science content only	0	-

This implies that the syllabus statements are not aligned. The contradictions in the syllabus statements can be related to the science panel's lack of understanding of what technology inclusion into science means. This mismatch can further be assumed to portray how the curriculum development process was carried out by the panel. It is possible to suggest that the panel was not critical enough during the process of curriculum development; if they had been, the mismatch could have been noticed. This highlights the argument raised by Eisner (2004) and Ornstein & Hunkins (2004) in which they suggest that curriculum developers who hold the technocratic perspective to curriculum development are likely to focus more on the process of curriculum development than to critically examine the different stages.

Ornstein & Hunkins (1993) show that curriculum developers state general objectives which are long term statements and proceed to develop them into a series of objectives which are more specific. For this reason, the Lesotho general objectives were broken down to specific objectives in the syllabus in order to achieve more specific statements of intent. Analysis of the specific objectives using the SAS depict the science, technology and society (STS)

approach as the most preferred approach to the incorporation of science and technology. The results of this analysis are shown in Table 10.

Table 10 *The science and technology approaches as depicted in the specific objectives*

Technology approach	No. of specific objectives	%	Example
Technology-as-an-illustration	2	5%	Be able to identify and apply the scientific knowledge and skills outside the classroom. (Ministry of Education and Manpower Development, (2002: 5).
Cognitive-motivational-approach	0	0%	-
Technology as an artefact	0	0%	-
Technology-as-a-process	10	26%	Be able to produce an item from an original design (blue print) Ministry of Education and Manpower Development, (2002: 7).
Science and technology and society	24	64%	Be able to identify and interpret the influence of technology on socio-economic aspects of life. Ministry of Education and Manpower Development, (2002: 7).
Science content only	2	5%	Be able to use/operate scientific instruments in appropriate situations. Ministry of Education and Manpower Development, (2002: 7).

The results show that sixty four percent (64%) of the specific objectives related to STS. Twenty six percent (26%) were linked to technology-as-a-process, five percent (5%) to technology-as-an-illustration and another five percent (5%) to science only. The important point to note here is that in general terms there is agreement between the general objectives and specific objectives. The issue is how these statements would be translated into what should happen at classroom level in order to achieve the stated curriculum objectives.

The learning outcomes

The learning outcomes in the syllabus were divided into the three science subjects namely: physics, chemistry and biology. The biology topics included: sense organs; use of scientific instruments; and diversity of organisms; cells; reproduction; nutrition; abuse of drugs;

common diseases; and environment. The chemistry topics were: experimental techniques; the separation methods; particulate nature of matter; atomic structure; periodic table; and the distinction between metals and non-metals. Physics topics were fluid pressure; force; equilibrium and centre of gravity; energy; simple machines; current electricity; thermal energy; and waves. The topics do not suggest integration at all. The syllabus content as stated has nothing to do with technology. The integration that is suggested is not visible through the content prescribed. The Botswana science curriculum which has adopted the STS approach has topics such as “water for living” (Nganunu, 1988), which suggest a different approach to science content even before going into the details of what the topic entails.

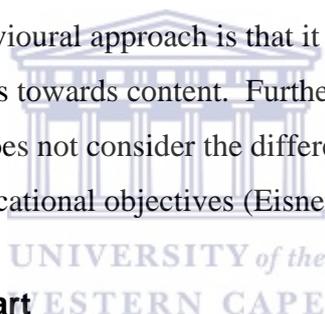
The SAS was used to classify the learning outcomes. The learning outcomes analysed were the Form A learning outcomes in Physics. The topics selected were: electricity, pressure and waves. “Electricity” had six learning outcomes, “waves” and “pressure” had seven each. A total of twenty learning outcomes were analysed. The results of the analysis are as shown in Table 11.

Table 11 The science and technology approaches as depicted in the learning outcomes of the selected physics topics

Technology approach	No. Electricity learning outcomes	No. Waves learning outcomes	No. Pressure learning outcomes	Total	%	Example taken from any of three selected topics
Technology-as-an-illustration	3	2	2	7	35%	Describe applications of fluid pressure in everyday life
Cognitive-motivational-approach	1	1	1	3	15%	Identify producers and detectors of waves
Technology as an artefact	2	0	0	2	10%	Connect a three pin plug
Technology-as-a-process	0	0	0	0	0%	-
Science and technology and society	0	0	0	0	0%	-
Science content only	0	4	4	8	40%	Relate amount of pressure to difference in height

An examination of Table 11 shows that the most frequently encountered learning outcomes deal with the content of science with no reference to the technology inclusion. The technology and science approach which seems to appear more often among the learning outcomes is technology-as-an-illustration. The learning outcomes show that the syllabus has shifted from advocating the STS approach to science content and technology-as-an-illustration approach.

The learning outcomes in the science-technology syllabus were intended learning outcomes. They were therefore stated in behavioural terms. According to Layton (1993: 43), technology education courses that use the STS approach contribute to technology education through awareness. That is “awareness of personal, social, moral, economic and environmental implications of technological developments”. Awareness is attitudinal and a curriculum that uses behavioural objectives that are stated in specific terms can not easily produce learning outcomes which relate to ‘awareness’. Learning outcomes related to technology through an STS approach would not likely to appear in this syllabus. As argued by Ornstein & Hunkins (1993) the limitations of the behavioural approach is that it fails to provide guidelines for showing appreciation and attitudes towards content. Furthermore, one of the weaknesses of the technical approach is that it does not consider the different ways in which subject matter can affect precision in stating educational objectives (Eisner, 2004).



The scope and sequence chart

Although the scope and sequence chart appears at the end of the syllabus document, the scope and sequence chart was developed after the development of the specific objectives. The scope and sequence chart showed how the science content was sequenced from Form A (grade 8) to Form E (grade 12). Each of the three science disciplines (biology, physics and chemistry) was sequenced on its own. Hence, the scope and sequence chart suggested no integration among the three science subjects. Technology was not visible in the sequence. It is likely that technology was not considered when the science content was being sequenced. It can therefore be inferred that the science content was sequenced first and technology was fitted where possible during the development of learning outcomes. Hence, the technological artefacts and issues appeared mostly as illustrations of the science content among the learning outcomes. The scope and sequence chart for the Lesotho science-technology syllabus is found in Appendix 5.

As indicated earlier in this chapter the curriculum design adopted for the science-technology syllabus seemed to be in conflict with the concept of integrating science and technology. The scope and sequence chart as described shows a vertical design. Hence it focuses only on science. Consequently, sequencing of content did not give any reference to technology. This suggests an unsuccessful attempt at integrating the two areas. If they were integrated the scope and sequence chart could have shown sequencing that depicts the integration of science and technology.

In summary, the analysis of the syllabus shows that the *teaching approaches* and the *assessment strategies* were aligned with a technology-as-a-process approach. The *general objectives* and *specific objectives* emphasised an STS approach. The *learning outcomes* were skewed towards science content on its own and technology-as-an-illustration approach. This illustrates a mismatch between the different syllabus statements. This can be considered to illustrate the uncertainty which the science panel had about the integration of science and technology.

It is argued in this section that this mismatch can be attributed to the curriculum development approach that the science panel adopted. As pointed out, there is evidence to suggest that the science panel viewed curriculum development as a technical undertaking. Consequently, they emphasised the process of developing the curriculum. Hence, little attention was given to the output of the process. The panel ought to have noticed the mismatch between the different curriculum statements. Otherwise, it can be supposed that they did not critically engage in the process of developing the science-technology syllabus.

5.2.5 The Textbook

As indicated in Section 5.2.2, three textbooks were written for the syllabus. The three textbooks were for Form A (grade 8), Form B (grade 9), and Form C (grade 10). For purposes of this study only the Form A textbook was analysed. The analysis focused on only three topics namely, electricity, pressure and waves. The textbook was analysed using the Textbook Analysis Schedule (TAS). The TAS was used to classify the different sections and heading in the textbook according to the following approaches: technology-as-an-illustration, technology-as-an-artifact, technology-as-a-process, cognitive-motivational-approach and science technology and society. These are the approaches suggested by Gardner (1990). The detailed explanation of these approaches is found in Chapter Three. The sections or headings that did not show any incorporation of science and technology were classified as “science”.

Furthermore, it was possible for one section or a heading under one topic to depict more than one approach. The analysis resulted with in a frequency table which indicated the frequency of occurrence of each of Gardner's approaches.

The Textbook structure

The cover pages of the Form A (grade 8) textbook are very colorful. The cover depicts Lesotho terrain and a big picture of the microscope and cells as viewed in a microscopic field. The textbook contents page shows the following topics: becoming a scientist, exploring matter, life and living, how are living things made, energy and its uses, electricity and magnetism, healthy living, forces and science around us. Almost every page of the textbook has a picture. The pictures were in the form of cartoons and photographs. Some of the photographs illustrated learners performing activities in the laboratory while others showed some technological artifacts. For example, there is a picture of learners performing experiments using the microscope and the picture of a man taking a chest X-ray. Some pictures show the local technologies such as the girl cooking with a three-legged pot and holding the pot-cover with a piece of cloth. The same picture shows the other children sitting around the fire covered with their blankets. Almost every page of the book includes an activity. In most cases these activities are prescribed experiments.

Scanning through this book it is difficult to make the judgement that it does not deal with technology integrated with science. The book has deviated from the traditional textbook which would include a lot of science content; it is therefore not a complete reference textbook for teachers or learners. Instead, it appeared more suitable for guiding the teachers on activities and experiments on different topics.

Chapter titles in the book have also changed from the old science s which would use scientific concepts as titles. However the textbook chapter titles are not the same as those found in the syllabus. The chapter titles give an impression of an integrated curriculum while the syllabus uses the scientific concepts as titles. For example, the syllabus has the topic "waves" and in the book the same content area is given the title "invisible science" and the topic "science around us". Given that this textbook was the only exemplary material on the science-technology curriculum the difference between the titles of the textbook topics and the syllabus topics could have confused teachers. The book chapter however gave an impression of an integrated curriculum.

Each chapter of the book starts with an introductory diagram. The introductory diagrams in most cases capture what is being discussed in the chapter. Below each introductory diagram

there are introductory questions, which relate to the diagram. This is followed by an introduction, which highlights the content of the chapter. The introduction is followed by the outline of the chapter objectives. The sub-headings of the chapters have activities and a brief outline of the content related to the activities.

It is common in this book to find different content areas to be under the same chapter. For example, electricity and magnetism appear in the same chapter. The book sometimes brings different science disciplines together under the same topic. For example the chapter “science around us” includes topics from physics, chemistry and biology. This may suggest an attempt to integrate the different sciences but this is not since the topics related to the different science disciplines can be easily identified within the chapter. The following example illustrates: the chapter “science around us”, has a section on energy. The concepts of energy that are treated under this topic are mainly biological. There is another section on metals; this section also deals with metals from a chemical perspective only. The section on metals could have treated concepts related to metals from other science subjects. For example, in physics conduction of both heat and electricity can be related to metals and these content areas can easily fit into the section dealing with metals. This could have shown the connections between the different concepts from different science disciplines. Consequently, technological applications could easily be treated in breadth. Separating concepts as is done in this book does not support STS approach because STS issues by their nature tend to draw content from different science subjects (Fensham, 1988). The Lesotho science-technology syllabus has arranged the content areas under separate subjects, and as such integrating them in the textbook would be contrary to what is found in the syllabus.

The chapter “electricity and magnetism”

The whole chapter on electricity and magnetism is studied in order to understand it fully, but the analysis of the chapter mainly focused on electricity. As mentioned in the preceding section the textbook sometimes brings two topics together that appear in the syllabus as separate topics. For example, electricity and magnetism are treated in the same chapter. Other than this, no effort was made to integrate the two topics. They are treated as if they were neither conceptually related nor have any application for each other.

The introductory picture in this chapter is the scenery at a battery-charging workshop. These types of workshops are common in Lesotho, especially in the rural areas where there is no electricity. Most people in these places use car batteries as a source of electricity for radios and television and they recharge their batteries at the battery-charging workshops. The

questions that follow the introductory picture are based on the picture. They generally seemed to be questions which were meant to make learners focus on batteries as sources of energy. For example, two of the questions are: “What are batteries used for? What other energy source can you use instead of batteries?” (Mpeta *et al.* 2000:116). The introductory paragraph focuses on the uses of electricity and the sources of electricity. Looking at the introductory diagram, the questions that followed it and the introductory paragraph, it appears that the central concern of the introduction was to motivate learners to focus on electricity. In terms of Gardner’s (1990) model of an inclusive science and technology curriculum the chapter emphasizes a cognitive-motivational-approach. This is because the technological artifacts, which appear in the chapter, appear early in the instructional sequence in order to stimulate interest and to relate learning of electricity to the context of Lesotho. The introductory section does not refer to magnetism. Based on the introduction it appears to the reader that the chapter is about electricity only. The scenery at the hydro-electric power station could have captured the two topics. Such scenery exists in Lesotho as part of the Lesotho Highlands Water Scheme at ‘Muela. The hydro-electricity power station at ‘Muela is very popular among teachers; schools in Lesotho visit this place often.

Sections of the chapter on electricity consist of the following sub-sections: electrical cells, connecting bulbs, safety first, wiring a plug, earthing and what to do when someone gets an electric shock. The section on electric cells starts with the experiment on a simple cell. This is the wet cell, which is used to show that the cell consists of the electrode, and the electrolyte, which is usually made of an acid electrolyte, copper electrode and zinc electrode. The section then compares the simple cell with a dry torch cell. The activity suggested here would have learners to open up the torch cell in order to see the different parts of the cell. The section ends with a summary, which explains the difference between a primary and a secondary cell. It also gives examples of primary and secondary cells.

The section on connecting bulbs also starts with a section on simple electrical circuits. This section requires learners to connect cells in parallel and in series and to identify which circuits show brightness best. It also entails connecting bulbs in series with a different number of cells and still identifying the difference in brightness between bulbs. The section ends with an activity where learners are asked to make a torch using materials that are suggested in the book. Except the part where learners are required to design a torch the rest of the content is quite familiar in physics when teaching electricity. The section does not suggest integration of any kind.

The section on safety includes a diagram depicting different types of electrical hazards on a diagram. This section requires learners to look at a diagram and to discuss the different electrical hazards. Learners were to deal with electric current in the next grade. The treatment of electrical hazards is not connected to scientific content that teachers were treating in Form A. Although it is important for learners to know electrical hazards, the section lacks continuity with the section that deals with cells.

The next section requires learners to connect a three-pin plug. In terms of “earthing” the book discusses “electric shock” and how earthing electrical appliances could help reduce the risk of an electrical shock. The last section of the chapter on electricity provides a list of guidelines for dealing with electric shock. The chapter then continues with magnetism. The chapter review poses recall questions on what was covered in the chapter. There is another section which is meant to make students think more deeply about what they have studied in the chapter. This section was referred to as “extend yourself”. This section contains nothing on electricity.

The results obtained from the analysis of this chapter using the TAS indicated that other than the science content which the chapter focuses on, the approach to the incorporation of science and technology that occurred more often was that of the technology-as-an-illustration approach. The results obtained from the analysis are as shown in Table 12.

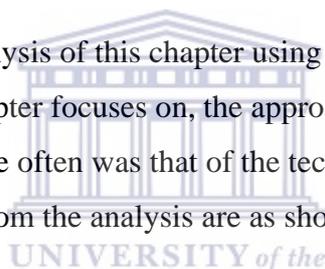


Table 12 Science and technology approaches depicted in “electricity and magnetism” with respect to electricity.

Technology approach	No. of sections	%
Technology-as-an-illustration	3	23%
Cognitive- motivational-approach	2	15%
Technology-as-an-artefact	2	15%
Technology-as-a-process	1	9%
Science and technology and society	2	15%
Science only	3	23%

In short the chapter on electricity has attempted to include technology in the science content. However, science content on its own seems to appear in a more noticeably manner. Results

shown in Table 12 indicate that all the approaches suggested by Gardner (1990) appear in this chapter. However the approach used more often in the incorporation of science and technology was technology-as-an-illustration approach. This approach suggests technology as an application. The motivation for the latter view of technology usually promoted to enhance understanding of the scientific principle and concepts through the use of interesting applications of real life (Gardner, 1990). It can be deduced that the STS approach which the syllabus objectives advocated has not been successfully translated into this chapter. In other words the panel appear to have failed to represent their intentions. The science panel was knowledgeable of the intentions of the science-technology curriculum. Consequently it would be expected that they should be able to translate the curriculum objectives into the textbook. Failure to do so, as it happened in this case, supports the view held by the researcher that the science panel approached the task of integrating science and technology without understanding the demands of this curriculum area.

The chapter “science around us”

Topics “pressure” and “waves” are both found in the chapter titled science around us. The introductory picture shows living and non-living things around us and in the playground. Although the picture is crowded with many things, there are those few that can be easily recognized such as children playing in the play ground, people reading, birds on trees, a bridge, a wind mill and the sun. The questions that follow the introductory statement are not necessarily related to the diagram. One of the questions reads: “In order to live, what things do plants and animals need?” None of the introductory questions relates to either “waves” or “pressure”. The introductory paragraph like the introductory picture focuses on the living and nonliving things. Without assuming that pressure and waves are part of nonliving things it is difficult to relate this introduction specifically to the topic “pressure” and “waves”. The introduction fails to show integration of the topics in the chapter.

The topic “pressure” and “waves” have only one objective each in a list of ten objectives for the chapter. The objectives for the chapter are actually the learning outcomes from the syllabus for the different topics. In other words, the list of syllabus learning outcomes is written as objectives of the chapter. Bringing more topics in one chapter meant writing a long list of learning outcomes. It could be assumed that in avoiding the long list some of the learning outcomes had to be omitted. As a result the topics pressure and waves ended up with one learning outcome each in the list. This suggests that the learning outcomes of the different topics needed to be arranged in a different form in the textbook in order to include

all of them. For example, learning outcomes which were conceptually related could have been grouped together such that they showed integration.

The chapter consists of the following sections: useful resources for humans; energy; extraction of fossil fuels; separating mixtures of liquids; plants as resources; other uses of plants; deforestation; soil erosion; pollution of the land; pollution of the atmosphere; avoiding pollution; plants and the environment; endangered species; water; water properties; sources of water; collecting water; uses of water; making water clean; pressure with depth; applications of fluid pressure; pressure of the atmosphere; filtration-separating solids and liquids; metals and minerals; properties of metals; where do metals come from; what do we use metals for; alloys; chromatography; invisible science; visible light; infrared radiation; ultraviolet radiation; microwaves; X-rays and gamma-rays; and radio waves.

The sections relating to pressure are: water and pressure, pressure with depth, applications of fluid pressure, and pressure of the atmosphere. The analysis of the book on the topic pressure only focuses on these sections. The sections which relates to waves are: invisible science; visible light; infrared radiation; ultraviolet radiation; microwaves; X-rays; gamma-rays; and radio waves. As indicated earlier the chapter topics suggest an integrated curriculum but the content of the topics deviate from integration.

Science around us dealing with pressure

As indicated in the preceding section, the sections of the chapter relating to pressure are water and pressure; pressure with depth; applications of fluid pressure; and pressure of the atmosphere. The section on water and pressure discusses the path that is taken by water to move from the ground to the taps. It then shows a diagram of two taps one with a high pressure and the other with low pressure. This is followed by an activity which involves using a drinking straw. The section then introduces learners to suction pressure. The activity with the drinking straw is not explained but it is simply followed by questions. This was found to be a very difficult section to follow. It is doubtful if the learners covered the topic thoroughly. The activity with the drinking straw uses the concept of atmospheric pressure. An attempt to explain how water comes out of a tap when one opens it is also not clear. The excerpt below describes how water comes out of the tap as explained in the book:

To get water coming out of the tap, you open the tap. This lets the water at the top of the pipe to come out. When this happens, the space which the water occupied can not be left empty. Water therefore comes from below to fill it up. This illustrates suction pressure, which is created when there is 'nothing' at the top, which needs filling, and pulls things from below. The pressure of water pushes it up to fill the space. You saw this in the experiment (Mpeta *et al*, 2000:183)

The explanation of how water comes out of a tap is related to pressure but it is important to show where the water comes from. If it is from underground to the top of the tank there is usually electrical energy, which is used to pump the water into the tank. If it is a borehole with a manual tap, which is common in many villages in Lesotho, there is mechanical energy required to pump water from the ground. In some cases gravitational force is used to transfer water from a high level to the lowlands. The explanation in the book assumed that as long as there is a tap the water can easily come out of the tap when one opens it. It can be assumed that the explanation above deliberately ignored the issue of energy because the focus of the book was on pressure. However it is not easy to deal with how the tap works without reference to energy. As a result, learners were not likely to follow how the tap works. The tap became an example of an artifact which uses the concept of pressure.

The section on pressure with depth refers learners to the elevated water tank and brings in the idea of gravitational force, which helps the water to flow. This section also deals with an activity of a tin with three holes either at the same height of the tin or at different heights. This illustrates that water at the bottom of the tin has higher pressure than at the top and water pressure at the same depth of the tin is equal. The chapter ends with an activity where learners are required to investigate whether pressure is affected by the shape of the tin. As gathered through experience the experiment of the tin with three holes is common in physics textbooks (e.g. Johnson, 1987; Duncan, 2000). It is usually used to illustrate that pressure increases with depth. The elevated water tank uses the same principle as the tin with three holes as far as positioning the tap is concerned. As a result the treatment of the water tank in this case was only an application of the scientific content on pressure.

The section on applications of pressure starts with activities which called for a visit to a large store and a garage. Learners were to investigate out how items in the shop are lifted, how cars are lifted and how petrol is pumped into a car. These applications are not explained and the book only provides diagrams on these. The extract from the book in Figure 5 shows the activities on the applications of pressure.

As indicated in the section dealing with the textbook structure, this book can not serve as a reference for more elaborate scientific content and technological knowledge. The

technological applications dealt with in Figure 5 are just examples. Consequently, learners are not likely to acquire both scientific knowledge and the understanding of the technological applications. Furthermore, the working of the technological applications given in Figure 5 does not deal with straight forward physics concepts. As such many science teachers can find it difficult to explain these concepts to learners in Form A. (Cajas, 1999). As indicated by (De Vries, 2006), the explanations of many scientific and technological innovations need more complicated scientific knowledge. This knowledge is not usually at the cognitive level of school learners. Hence, in an attempt to integrate technology the book has only dwelled on examples. These examples compromise the development of scientific and technological knowledge.

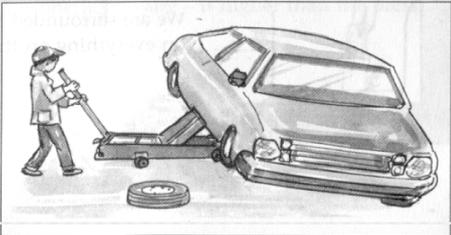
Applications of fluid pressure

Activity
Visit one or more of these places.

- A large store or supermarket. Find out how heavy objects are lifted from the ground to higher places like shelves.



- A garage or motor clinic. Find out how cars are elevated when they are being repaired. Here you can also find out how motorists use hydraulic car jacks when they want to change the wheels of their cars.



→

- A filling station. Where is the fuel (petrol or diesel) kept in the station and how is it pumped into the vehicles?



Figure 5 activities on the applications of fluid pressure extracted from the textbook.

The last activity is on siphoning. The activity has a diagram illustrating siphoning and learners are asked questions about it. No attempt is made to explain siphoning at all. The section on pressure and the atmosphere starts with a short explanation of the fact that air exerts pressure on earth. It then requires learners to use the syringe. Learners are then asked to heat air inside a closed container and then cool the container by putting it under running

cold water. The explanation of this activity is based on pressure. The explanation in the book reads as follows:

In the oil-tin experiment, as the steam inside the tin cools it condenses and pressure inside the tin decreases. The tin collapses because the air pressure outside the tin-the atmospheric pressure - is higher than inside the tin (Mpeta *et.al*, 2000:187).

The explanation is brief. A more elaborate explanation would require the use of the kinetic molecular theory. Condensation as an explanation for the decrease in pressure does not make it easy for learners to follow what is taking place in this process since condensation is also a process that needs to be explained. It is possible that the learners might not have dealt with kinetic theory. According to the syllabus sequence it appeared in the next grade.

The chapter review includes only one recall question on pressure and there is nothing on pressure in the “extend yourself” section. Table 13 shows the science and technology approaches as depicted in the textbook chapter on “Science around us” with a focus on “pressure”.

Table 13. Science and technology approaches as depicted in the chapter “science around us” focus on pressure.

Technology approach	No. of sections	%
Technology-as-an-illustration	1	13%
Cognitive- motivational-approach	4	50%
Technology-as-an-artefact	0	0
Technology-as-a-process	0	0
Science and technology and society	0	0
Science only	3	37%

As shown on Table 13 among Gardner’s (1990) approaches the most commonly encountered in this chapter is the cognitive-motivational approach. The technological artifacts in the topic “pressure” were used to motivate learners in learning concepts associated with pressure. The artifacts were hardly related to the scientific concepts and principles associated with them. The section concentrated on examples of technological applications and as such, the science content and the knowledge associated with the technological applications are compromised.

Science around us with respect to “waves”

The section on waves is referred to as “invisible science” in the book. This section consists of the following sections: visible light; infrared radiation; ultraviolet radiation; microwaves; X-rays; Gamma-rays; and radio waves. The section starts by introducing electromagnetic waves showing that the largest part of the electromagnetic spectrum is invisible except visible light.

The section on visible light is very brief and comprises only three lines. It mentions how the light is produced, how it is detected and showed the different colours of visible light. The part on infrared radiation starts by showing how infrared rays can be detected, and how they are produced. A photograph of the thermograph of a hand shows the application of this concept in medicine. It further shows that infrared rays are used in cooking food on stoves.

The section on ultraviolet radiation indicates that ultraviolet rays are dangerous and can be detected by the skin. The importance of ultra violet radiation is also mentioned, namely that it helps the human body to produce vitamin D. The section then shows photographs of people sunbathing. The process of skin turn is explained in a small box labeled, “Did you know”. It ends with a warning, that too much exposure to sunlight causes sunburn and can also cause sunstroke as well as skin cancer. Generally the technological artifacts are treated in a superficial manner. It suggests that teachers would be expected to elaborate on them when teaching. On the other hand, this book is supposed to represent exemplary teaching material. Hence, in some way it suggests that technological artifacts should just be treated as examples. It also suggests that scientific content is not important.

The section on microwaves deals with how the microwave oven cooks food and the use of microwaves in telephone exchange. It is a brief explanation, which is followed by a diagram of a microwave oven and a microwave transmitter. The explanation read:

Microwaves in the microwave oven cook food by causing water molecules in food to vibrate more quickly. Microwaves are also used to carry telephone conversations between exchanges (Mpeta *et al*, 2000:200)

This explanation can be very difficult for somebody who has not seen a microwave oven and has to understand what a microwave is. To understand how the telephone messages are transmitted through microwaves would also not be understood through the use of an example. In the case of Lesotho many learners have not seen the microwave oven and some do not have access to telephones. These are just abstract ideas. Learners are not likely to understand these technological applications. It can be assumed that they remain as examples which do not benefit learners.

The section on X-rays and gamma rays also deals with how they are produced and how they can be detected. The explanations are accompanied by a photograph of a man taking a chest X-ray for tuberculosis and the photograph of the doctor examining the patient's X-ray results. The pictures in this section could only help to remind someone who had taken an X-ray in a hospital what an X-ray is. The section also has a warning, which indicates that too much exposure to X-ray is very dangerous.

The section on radio waves starts with an explanation by showing the producers and detectors of radio waves. It further indicates that radio waves are used in cordless telephones as well as in televisions. It then shows a diagram of an aerial transmitter transmitting waves to a radio receiver, to a television and a satellite dish. The chapter does not contain any questions on waves. The "extend yourself" section requires learners to investigate how the television works and compares it with the working of the radio. It further requires learners to find out how infrared radiation is used in medicine. Table 14 shows the science and technology approaches depicted in the textbook regarding waves.

Table 14 Science and technology approaches depicted in the chapter regarding "waves"

Technology approach	No. of sections	%
Technology-as-an-illustration	7	70%
Cognitive- motivational-approach	0	0
Technology-as-an-artefact	0	0
Technology-as-a-process	0	0
Science and technology and society	0	0
Science only	3	30%

In most cases technology in this chapter was used as an illustration as indicated in Table 14. There was no attempt to describe the artifacts and how they worked. In addition the chapter failed to relate the working of the artifacts to scientific principles and concepts. For example, the explanation of microwaves which is given in the previous quotation indicates that microwaves are used for cooking and communication. The scientific principles associated with this type of waves such as their frequency, wave length, type of waves and their position in the electromagnetic spectrum is neglected. In other words the approach in the section does

not allow learners to develop both the science and the technological knowledge. Another important point about “waves” as treated in this chapter was that most of the examples that were used were not familiar to learners. The thermograph of a hand, skin sun bath, and microwaves transmitters are examples which are unfamiliar to Lesotho learners. Such examples could make it difficult for learners to follow the lesson.

In summary, the analysis of the textbook has shown that there has been an attempt to incorporate science and technology. The most commonly encountered approach to integrating science and technology in the book is technology-as-an-illustration. Table 15 shows on average how the different Gardner’s (1990) approaches were used in the book regarding electricity, pressure and waves. Technology-as-an-illustration approach is supposed to enhance the acquisition of scientific content and principles as indicated by Gardner (1990). The book seems to have failed in terms of using the technology-as-an-illustration approach to support the acquisition of science content. This is because the technological applications are given as examples in a science topic. No effort was made to relate the application to the underlying scientific content and principles. As such, the book does not do justice to both the scientific content and technological knowledge and capabilities. Scientific content also appeared on its own quite often. This indicates that it was difficult for the panel to come up with technological examples.

These results suggest that the textbook does not support the STS approach although STS was the intended approach. In following this book teachers could be expected to continue to teach science as usual without integrating it with technology. Where teachers would bring in technology they will use technology to illustrate the scientific concepts they have taught. As such the book has failed to represent the objectives of the syllabus. Therefore as an example of material for the planned curriculum, this book has limitations.

Table 15 Percentage use of the approaches to the teaching of science incorporated with technology regarding electricity, pressure and waves.

Technology approach	Science & technology approach per topic in %			Total	Average
	Electricity	Pressure	Waves		
Technology-as-an-illustration	25	13	70	108	36.0
Cognitive- motivational-approach	17	50	0	67	22.3
Technology-as-an-artefact	17	0	0	17	5.6
Technology-as-a-process	0	0	0	0	0
Science and technology and society	17	0	0	17	5.6
Science only	25	37	30	92	30.6

5.2.6 The junior secondary examination

The researcher was the subject officer for mathematics and science at ECoL and was responsible for the JC science examination questions papers every year. As a result she was familiar with the test specification of the JC science papers. As indicated in Chapter One, the questions are developed by the examiner and moderated by the panel of moderators. The science examinations consisted of two papers. Paper 1 consisted of forty-five multiple-choice questions. Of the 45 multiple-choice questions, 15 questions were biology questions; another 15 each were chemistry and physics questions. All the questions belonging to the same science discipline were grouped together in the paper.

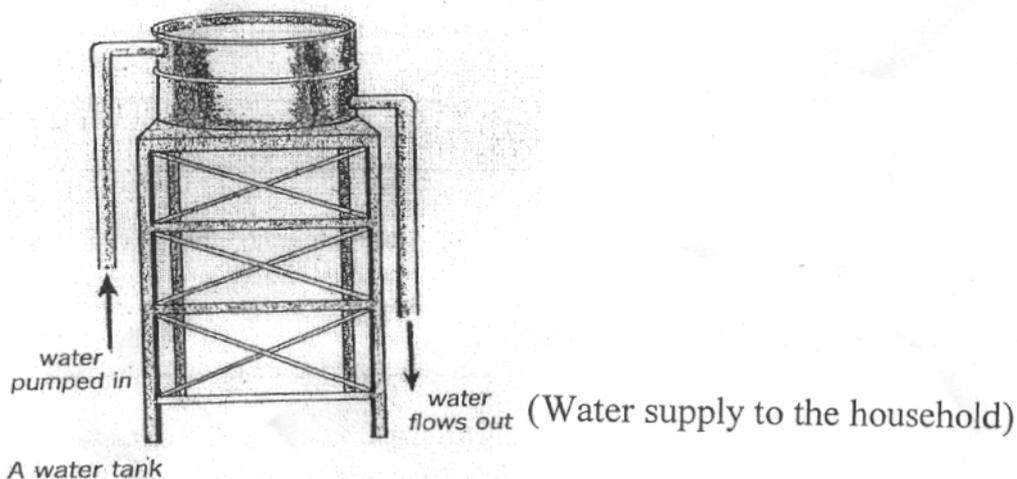
Paper 2 was divided into two sections. Section A consisted of three questions. The three questions focused on biology, physics and chemistry respectively. Section B also consisted of three questions. Question one was intended to test environmental science, question two was to test scientific skills and question three, technology. The three questions in section B were supposed to reflect biology, physics and chemistry. It had been common practice to base the environmental science question on biology, the scientific skills question on chemistry and the technology question on physics.

Since the focus of this study is on the inclusion of technology in the science curriculum it seemed appropriate to highlight an example of questions which attempts to assess the issue of

- (i) What is the reason for her suggestion?
- (ii) What would happen if the tank is placed at a lower level than the absorbing panel?
(Examinations Council of Lesotho, 2004:15)

Question 2

- (a) The diagram shows an elevated tank used to store water from the borehole.



- (i) What is the reason for placing the outlet pipe at the bottom of the tank?
- (ii) Why are water storage tanks often elevated?
- (iii) What would happen to the pressure of water if the outlet pipe is placed at the middle of the tank?

(b) Mr. Thabo has a borehole, and the water from his tank does not come out with enough pressure to allow him to water his plants.

- (i) What should be done to the pipe from the tank to increase the pressure of water?
- (ii) What would happen if the inlet and the outlet pipes are at the same level?

(Examinations Council of Lesotho, 2003:14)

Although it might not have been easy to indicate how learners ought to have been taught in order to respond to questions like the two above, the questions showed an attempt to test science integrated with technology. In order to respond to the 2004 question (a) (i) (ii) above the learners could recall the information since it is possible that they might have been told what fossil fuels are and probably have discussed some renewable energy sources. Dealing with renewable energy sources can be associated with STS approach. However for question (b) the student should have been exposed to the working of this artefact. The learners should know the parts of the solar water heater or a similar device. This relates to technology-as-a-process approach. They further need to know the functions of the different parts of the solar

heater and be able to relate them to the associated scientific principles. This could involve technology-as-an-illustration approach or cognitive-motivational approach. It could only depend on when the teacher dealt with the application. The questions also required content from different content areas of physics. For example, heat transfer and pressure.

Even though the water tank depicted in question 2 of 2003 examination was quite common in Lesotho, knowing how the different parts of the water tank relate to the scientific principles required some level of familiarity with the underlying concepts of energy and pressure. At least four of Gardner's (1990) technological models are involved such as: technology-as-an-illustration, technology-as-an-artefact, technology-as-a-process and to some extent the STS approach. In short the JC science examination question papers have attempted to assess technology integrated with science.

5.2.7 The experts' perceptions of the nature of the science-technology syllabus

The analysis of the syllabus document indicated that at the level of the objectives it encouraged the STS approach. However, in terms of the learning outcomes, the dominant approach was technology-as-an-illustration. To gain additional insights, experts who were involved in the development of the science-technology curriculum were interviewed in order to establish what the objectives of incorporating technology with science were and how they had planned the curriculum would achieve these objectives.

As stated in Chapter One, the panel invited experts from the field of technology to assist in the development of science-technology curriculum. The curriculum experts involved in the development process included science educators, technology educators and technologists. The science educators in the panel believed that the science curriculum, which incorporated technology into science reflected the national goal of education. The government of Lesotho envisaged the provision of basic education to all Basotho as the central goal towards enhancing social and economic development (Ministry of Education, 2004). The science educators saw the science-technology curriculum as a means of achieving this goal. They argue that science-technology curriculum could contribute to the development of a scientifically and technologically literate society. When asked what she believed was the rationale behind incorporating technology into the science curriculum one science educator asserted that:

The inclusion of technology into the science curriculum was following the National Goal of Education. At national level science and technology are taken to be the prime subjects. In the 1995 Minister of Education speech, the Minister did indicate the need to have a public, which is scientifically literate. Education was therefore to play the key role in educating children so that they can be scientifically and technologically literate citizens.

Children should be prepared to have a science and technological background that can help them to survive in daily living. For example, making health decisions, good home habits such as economizing on electricity and being able to produce something for selling or using.

According to this science educator technology and science were integrated in order to enable learners to acquire scientific and technological literacy. Her discussion implied that the STS approach and technology-as-a-process were the envisaged approaches for the integration of science and technology. On the other hand the technology educator provided the rationale behind the inclusion of technology into science:

Technology is an important subject. It provides a person with baseline skills, which could help him/her to have life skills of producing, manufacturing services and design. It helps a person to think in a way that can help him/her to produce something to sell or to have skills that he/she can sell. I thought the syllabus would therefore touch on craft skills such as metal work, woodwork, technical drawing and welding. It could be accompanied by theory of design aspects.

The technology educator viewed the whole process of incorporating science and technology as a way of bringing the crafts subjects into the science curriculum. In fact he was not satisfied that woodwork, metal work, technical drawing and welding have not been included in the syllabus. The approach that the technology educator was advocating was the crafts oriented approach (De Vries, 1994). He also alluded to technology-as-a-process approach.

The technologist in the panel was more concerned with the issue of producing technologists. When asked the same question about the rationale for including technology in the science curriculum, he stated that:

Learning about these technologies is important because it could produce skilled manpower on the concept of renewable energies. This could be handymen who deal with small issues. The syllabus can be a way of disseminating some technologies. There are no handymen in the rural areas. They are needed, and hoped the school could produce such persons. Learners need to learn science and take it into everyday life context.

The panel members seemed to view the idea of technology inclusion into the science curriculum from the economic instrumentalist point of view. According to Layton (1994), economic instrumentalist do not see any difference between technology education and vocational education. They believe school leavers should be prepared to understand and use new technologies. If necessary they should be professionally prepared to use technology in

their chosen careers. The differences among the experts are reflective of their backgrounds and orientations. In terms of Gardner's (1990) model, their views range between technology-as-a-process approach to STS approach. Although the experts' views vary, their overall concerns as summarised below are in line with technology as the application of science.

Some of their suggestions include the need to:

1. Create interest by showing learners an application of an artefact, ask them how the artefact works, deal with the scientific knowledge and then relate scientific knowledge from different topics and design the artefact in question.
2. Start with what learners know and bring their experiences to the surface, trigger their interest through discussion, allow time for investigation and finally build a scientific understanding.
3. Start with the known or familiar technological applications; bring learners' experience to the surface before treating the scientific concept.
4. Start with the scientific concept, bring in the artefact and deal with the application.
5. Start with the application, allow learners to carry out investigations to reinforce their scientific conceptions and lead them towards the application of the concepts developed to their everyday life context.

Whatever perspective they may hold, the curriculum developers including experts saw the reason for incorporating technology into the science curriculum as enabling learners to become scientifically and technologically literate. This is in line with the national goals of education. The curriculum developers generally agreed with the incorporation of technology into school science in terms of some of the Gardner's (1990) themes.

5.2.8 Summary

Although the curriculum developers agreed on the objective for the incorporation of science and technology into the Lesotho science curriculum, they differed in the approach to technology education which they believed will best achieve this objective. Their views towards technology education seemed to influence the way they thought it should be incorporated. Most of them agreed that teachers should use technology-as-an-illustration or the cognitive-motivational-approach in an integrated science and technology curriculum. These are approaches which view technology as the application of science. However the curriculum reflected in the syllabus and the textbook is not an adequate reflection of this objective. It is also apposite to mention that integration of the two fields, namely, science and technology is easier said than achieved in reality. Even the integration of the three branches of science (physics, chemistry and biology) has not been easy. Despite this, it is evident that

the new curriculum and consequently the syllabus developed to implement the new curriculum strive towards the attainment of a scientifically and technologically literate society. Of the five science and technology approaches suggested by Gardner (1990), the most commonly encountered approach in the syllabus, the textbook and the JC examinations is technology-as-an-illustration. As indicated in the introduction to this section, curriculum studies are concerned with intentions and what really happens at classroom level as teachers try to implement the intentions of curriculum developers. The next section presents the results and discussions on the implemented LJSTC.

5.3 Section 2: the implemented curriculum

As indicated in Chapter Two and Three, there is a clear distinction between the planned and the implemented curriculum. A planned curriculum is only an idealization but an enacted curriculum is one tested in the context of the classroom. As Ogunniyi (1996) argued, any curriculum introduced into the school setting is not left in its naked form but it assumes a different form for that setting. Its contents are emphasised or deemphasised, explicated or attenuated as teachers, learners and administrators see fit for their particular setting. This section is concerned not with the idealised curriculum but the implemented curriculum in terms of how teachers and learners handle the inclusion of technology in the classroom under conditions that prevail at school level.

This section describes results obtained from the analysis of classroom observations, and interviews conducted in four schools fictitiously named Metheleng High School, Jake High School, Lelimo High School and Sofy High School. The results from the analysis show how the science curriculum with an emphasis on technology was implemented in the four schools. The observations were conducted in these schools during the teaching of the topic: pressure, electricity and waves. All the observations were carried out between April 2004 and November 2004 while the interviews continued until 2005. Due to the prevailing circumstances in the schools not all the three selected topics were taught during the study. At Jake High School and Sofy High School only waves and electricity were taught. At Metheleng High School all the topics were taught and observed. At Lelimo High School only electricity and pressure were taught during the study period.

As discussed in Chapter Three, the implemented curriculum was investigated using Stake's congruency and contingency model (McCornick & James, 1988). Stake's model only guided

the collection and analysis of data. The constant comparative approach (Merriam, 1998) was used to analyse detailed qualitative data that was obtained from the observations and interviews. This approach involves three levels of analysing and presenting data which are: descriptive account, category construction and analysis which involve making inferences, developing models, and generating theory (Macmillan & Schumacher, 2001; Merriam, 1998).

5.4 Antecedents

5.4.1 Introduction

In the school environment there are many antecedents which can support or destruct the implementation of the curriculum. The aim of this section is to discuss the findings of the study in relation to what was found to be the conditions in the schools that can be related to the interactions at classroom level hence the outcomes of the curriculum under investigation.

5.4.2 The setting

Metheleng High School

Metheleng High School is in the Berea district. The school belongs to the Methodist church. The principal of the school was a Ghanaian man who had been in Lesotho for some time. In this school only one science teacher taught all the science disciplines at junior secondary and this changed in senior secondary where teachers taught their major subjects. The timetable was arranged in double periods for all science lessons. As a result each science lesson took 80 minutes. There were three science lessons per week. The school had only one laboratory, which was reserved for senior secondary learners. All the Form A science lessons therefore took place in the classroom. The classroom was a typical Lesotho classroom with desks arranged in rows and a teacher's desk in front. Each desk in the classroom accommodated three learners. The classroom was crowded; its walls clean with no posters or charts. The science teacher at the school was not satisfied with the facilities. The quotation below summaries how Maria felt about the conditions in the school:

For example you find that I can only use the lab if one teacher is absent. I can have access to the lab by luck. Otherwise the time I spend collecting the thing from the lab, half of the lesson time is lost, when I could have set everything in the lab. And in the class the students can not work in groups you can see that we have desks that do not permit that. So they do not have hands on activities most of the time (Metheleng H.S, 8/05/2004).

The science teacher (Maria) who taught science in Form A at the school was a female teacher. Maria was aged 53 years and had started teaching in 1978. Given the number of years she had spent teaching, she was as an experienced teacher. She was a qualified science teacher with a Bachelors degree in science and a Diploma in education. Her major subjects were chemistry and biology. She taught all the science subjects (biology, physics and chemistry) to all the Form A classes. The Form A class that was observed had forty three students. She was soft spoken, and at ease with her learners. Her class was always noisy and not very much organised. Maria looked like she was used to the noise in her class, which in most cases was unbearable.

For every lesson she collected materials and laboratory equipment and brought it to class. In some cases the artefacts that she wanted to use were not available in the school laboratories. She therefore had to improvise or bring the artefacts from home. For example, when teaching waves she had to bring the microwave oven from home. Simple artefacts such as the electric kettle, the radio, the cell phone, car battery were not available in the schools. In some instance she drew the artefacts or brought pictures and in extreme circumstance she would just talk about the artefacts.

Maria's working space used to be full of materials to use in class, although sometimes she would not use all of it. Probably it is because in some cases she could not determine before the lesson what she would need or she could not finish what she intended to teach. According to her, she last had in-service training in 1997. This was long before the new science syllabus, which incorporated technology, was introduced.

Metheleng High School had a head of science department and a laboratory technician. The Head of Department of science was a middle-aged woman. She had a Masters degree in science education and had majored in chemistry and biology. She had 13 years of teaching experience and had no formal training as a Head of Department. She had only attended one in-service course in the past five years. However she was very comfortable with her work as the Head of Department. During our interview she indicated that her main tasks as the head of science department were to check schemes and records of work of her department teachers as well as to check laboratory supplies. She also organised any science-related activities like the "Science Fairs" in collaboration with her colleagues in the department (Metheleng H.S. 8/05/2004).

Jake High School

Jake High School is located in the Maseru district. It had a population of about 400 learners. The science department at this school had adapted the subject teaching system. In this system science teachers taught the component of the syllabus that they had specialised in. For example the physics specialist taught the physics component of the syllabus only, the chemistry specialist taught chemistry only and so on. In other words the science subjects were separated by teaching and appeared as such on the timetable. The science lessons were in double periods and each lesson took 80 minutes. There were three lessons per week for science and teachers shared the time equally. The science teacher that participated in the study had one lesson per week. The other two were for chemistry and biology. The science lessons were taught both in the classroom and the laboratory according to the teacher's preference or plan.

The laboratory at the school was a normal school laboratory with a fume cupboard, electric outlets, and gas taps. It was furnished with high fixed tables and benches. It also had a teacher's working space with an elevated table. Only two posters could be observed on the walls of the laboratory. One poster had the picture of the eye while the other illustrated laboratory rules. The chairs in the laboratory were sometimes not enough for the learners and some learners had to remain standing during lessons. It was not surprising that in most cases learners ran to the laboratory whenever they were going to have their lesson there. Due to shortage of equipment the learners had to be grouped into large groups when working on activities. The teacher as a result sometimes abandoned essential laboratory work and resorted to talking or illustrating with diagrams.

The classroom that was also used for science lessons had a broken door and windows. The learners sat on desks, which were occupied by three or four learners. The desks were arranged in rows and spaces between the desks were very limited making it very difficult for the teacher to pass. Most often the teacher had to stand in front of the class when teaching.

The school had the head of science department and a laboratory technician. The head of science and mathematics department at Jake High School was a middle-aged woman. She first became the Head of Department in 2003. She did B.Sc. and Post Graduate Certificate in Education (PGCE). She completed her studies in 1995 and had been a science teacher since then. She said her role was to coordinate science teachers as well as to act as a link between the science teachers, management and other departments in the school. She indicated that she

was also expected to oversee the science and mathematics departments as the teachers perform their routine work such as scheming (Jake H.S. 22/09/04).

The science teacher (Mr. Jobo) had Bachelors degrees in science (BSc) with specialisation in physics and mathematics. He had no teaching qualifications. He had taught physics for more than ten years. Mr. Jobo was a serious teacher hardly passing a joke in class. He was focused on his work. His learners were obedient. In most cases they talked only when he was asking questions or when they were given activities to work on. The opportunities for working on activities were rare in his class. He talked most of the time, and his teaching approach was heavily based on asking questions to the learners. He had a tendency of asking questions and answering them himself when learners could not answer.

Lelimo High School

Lelimo High School is a government school located in Maseru town. It is an old school, which was built during the British rule in Lesotho. The school is more than 70 years old. The school principal was an aged Mosotho man. The school had a young deputy principal who was very active and highly organised. Lelimo High School had a reputation of being a good school with excellent academic performance. It was regarded as one of the best schools in Lesotho by parents and most of them wanted their children to enrol in this school. As a result its admission standards were high. Most learners in this school were supposed to be top performers as indicated by the Primary School Leaving Examinations. The Form A teacher at the schools also supported the view that they are knowledgeable. During our interviews she said:

Yes, the Form As, sometimes I feel, they have too much background. Then whatever you teach ends up being like revision. I think they have enough background (14/09/04, Lelimo H.S.).

In this school the science lessons took place in both the classroom and the laboratory as per teacher's arrangement of the day. The school had four laboratories. The class that was observed during the study was using only one laboratory - the physics laboratory. The laboratory was very old, and it was furnished with high chairs that were movable and high desks, which were not movable. There were cupboards around the walls of the laboratory. In front of the laboratory there was a teacher working space which was elevated. The laboratory had gas taps, water supply system and gas supply taps. However most of the taps were broken and the teacher indicated that the gas and water supply taps were not working. It was evident that there was a shortage of equipment in the laboratories. The teacher improvised on

some materials. In some cases she asked learners to bring supplies from home. The science teacher (Lineo) often used diagrams to illustrate some technological artefacts that were not available in the school laboratory. The walls of the laboratory had only two charts.

The classroom, which was used for some science lessons, was well furnished with new desks, made to the size of the learners. The desks were designed for only two learners to occupy. There was enough space to move the desks around. In front of the classroom was the teacher's table with a chair. The walls of the classroom were very clean with no displays at all.

Lelimo High School had a head of science department and a laboratory technician. The Head of Department at Lelimo High School was an experienced middle aged man. He had a BSc degree and majored in biology and chemistry. He had completed post graduate studies in biology and at the time of the study he was pursuing a PHD in Environmental Science part time with the University of the Orange Free State. He has been teaching since he completed his graduate studies in 1987. He was new in the position of the head of Mathematics and Science. Due to his experience in teaching and his involvement in other activities such as the Lesotho Science, Mathematics and Technology Association he was quite confident. He had also published some science textbooks for the junior secondary level.

The science teacher (Lineo) at Lelimo High School was a young Mosotho woman. Lineo had Bachelors degree in science education (BSc. Ed). Her major subjects were physics and mathematics. She had five years of teaching experience. Lineo had a very soft voice. She was very much in control of her class most of the time. Lelimo High School was also using the subject system. Lineo was therefore teaching physics only across all levels. Among the teachers that were observed during the study, she was the only one at ease with using Sesotho during teaching whenever she felt her learners were not following what she was saying. The level of discussion between her and the learners was very high. Learners in her class displayed good background knowledge in science and general knowledge.

Sofy High School

Sofy High School is located in the Maseru district. The school is owned by the Lesotho Evangelical Church. It had a population of about 500 learners and its academic performance was average. Due to its location there was a lot of noise around the school. The noise from people shouting, music and cars from the street was heard from the classes especially the

science laboratory. The traffic and the activities in the streets were observable from the windows of the laboratory.

Compared with the laboratories of other case schools the laboratory in this school was bigger. It was furnished with high fixed tables and chairs. There were a couple of charts on the walls. The charts with the following titles were on the walls: our water our health, optics the study of light and optical instruments, the skin, ground water, the teeth, the periodic table and laboratory rules. The laboratory also had the fume cupboard, and the cupboards which were neatly labelled. Electrical, water and gas supply were also observable. The science lessons in this school were held both in the classroom and the laboratory. The lessons would normally start in the laboratory and end up in the classroom. The classroom was big enough to accommodate learners. Desks were arranged in rows and each desk was big enough for four learners. The desks were spaced enough to allow movement between them.

The school had adapted the subject system. That is, each specialist teacher taught his or her own subject. The physics teacher (Mr. Sofonia) was a middle-aged man. Mr. Sofonia had Secondary Teaching Certificate. He had majored in secondary science teaching. He had not specialised in any specific science subject, however he was regarded as the physics teacher in the school. His voice was not intimidating but made him gain control over his learners. Mr. Sofonia never finished any topic as prescribed in the syllabus. He had postponed most of the content he was to teach in Form A into Form B.

The teacher was absent at times when we had scheduled observation lessons. During my observation period we had to reschedule outside of normal hours for lessons. He made no specific excuse for his absence or missing our appointments.

Summary

The physical facilities in the four case schools were not very much different. Learners had access to the laboratory except at Metheleng High School. Even where there were laboratories, learners still had some of their science lessons in the classroom. The teachers decided when to teach in class and when to teach in the laboratory. The laboratories were similar and they generally lacked facilities.

The timetable arrangements were the same except that three of the case schools had adapted the subject teaching system and in one school the teacher was teaching all the sciences. All the case schools had heads of science departments and a laboratory technician. In most cases

the teachers were qualified teachers except that in one case school where the teacher did not have a teaching qualification. All case school teachers did not make lesson plans. They only schemed for the topics they were teaching.

The inclusion of technology into science required teachers to use other materials which are not normally required in the normal science laboratory. This placed strain on teachers who were using laboratories which lacked equipment. Consequently, teachers had to improvise or bring the artefacts from home. In some cases they had depend on pictures and diagrams. To assume that the normal science laboratory can cater for both science and technology did not seem realistic in this case.

As indicated in Section 1, the syllabus had separated the three science subjects. In a similar manner most of the case school had separated the science subjects on the timetable and in teaching. The different science subjects were taught by teachers who taught their own specialisation subjects. This arrangement did not support integration of science and technology. This issue will be discussed in detail in the subsequent sections.

5.4.3 Teachers' perceptions of the new science syllabus

All the schools in the study had heads of science departments who were qualified science teachers. However, science teachers had different educational backgrounds. For example, the teacher at Sofy High School had a teaching certificate, and the science teacher at Jake High School had no teaching qualification, but had a Bachelors of Science Degree. It is recognised that teaching qualifications have a role to play in the teaching of science. However in the case of this study, qualification did not seem to determine the way the teachers incorporated technology with science. On the contrary teachers' perceptions of the new science syllabus seemed to influence the way they taught science integrated with technology. All the science teachers in the study held the view that the science syllabus required them to apply science in every day life. Consequently they mainly used technology-as-an-illustration approach in teaching science integrated with technology. The following quotation indicates what Lineo the science teacher at Lelimo High School believed to be scientific and technological knowledge and skills that learners ought to acquire by experiencing the Lesotho science-technology syllabus:

Manipulation of instruments. That is explaining some observations which exist in real life. Basically to apply the knowledge to solve. Not to solve as such but to explain some observations that were encountered in everyday life, like how the car moves, why we place the outlet pipe on the tank at the bottom of the tank. These are some of the things that have already been done. The learners just explain them. I do not see much room for the learners to design things. Things like projects (Lelimo H.S 14/09/2004).

Lineo did not consider design as essential skills in the science-technology curriculum. She thought that as teachers they only had to explain how the artefacts work or explain some technological processes. Her emphasis was on applying scientific knowledge to real life.

The heads of science departments in the study also held the same view as science teachers regarding the science syllabus. The Head of Department at Jake High School had this to say about the science syllabus:

The children have knowledge of different disciplines of science and that knowledge should help them in daily life. They should be able to apply scientific knowledge taught in class in their daily life. I am sure we have to bring to their attention the fact that these are not only classroom materials but they can also be used in everyday life. In that way they begin to appreciate that what I am doing is not classroom science issue, it is not difficult and can actually help me in life. This is why even examples of vegetables are in Sesotho and even those that they do not know they should try to find them. That is if I want to have vegetables it is not only cabbage but there are other vegetables including wild vegetables. Applications like when you sieve tea, or porridge that can be related to filtration. Filtration is separation ...is not only separating soil and water but can be more than that. Filtration is something that separates solid and liquid and can be done in real life (Jake H.S. 21-04-2004)

The Head of Department believed that students should acquire scientific knowledge in order to apply it in everyday life contexts. In particular she wanted learners to be able to relate science they learnt from school with issues in real life. The perceptions that the science teachers and heads of science departments had about the science-technology syllabus were also common among the district science advisors.

The district science advisors worked with science teachers at school level. They provided in-service training for science teachers. Some of the duties of the district science advisors included holding workshops for teachers, making classroom observations, team teaching with teachers, performing demonstration lessons, conducting teacher clinics and other related duties (DRA 1.15 /6/2005, DRA 2.15 /6/2005, DRA 3.15 /6/2005). The Maseru district science advisor was responsible for all the schools in the study. The excerpt below shows what one of the resource persons believed to be the focus of the science syllabus.

I think the most important is the everyday examples. That is teaching every concept the teacher has to make sure that he/she includes the everyday examples. Again teachers need to help learners acquire skills of answering questions (DRA 15/6/2005).

Generally the science teachers, the heads of science departments, and science advisors perceived the science syllabus as the syllabus that applied scientific knowledge and skills in everyday life context. Hence, the science advisor believe that the best way of teaching science-technology syllabus is by teaching the science content and then bringing in the everyday examples. This implies that the advisors held the same view of the Lesotho science-technology curriculum as the science teachers and the heads of science departments.

Further interviews revealed that the science educators that participated in the study viewed technology as the everyday life context upon which science could be applied. According to Gardner (1994) this understanding of technology is common among science educators. When asked whether she believed the science syllabus incorporated technology the head of science department at Jake High School said:

Is this technology the application of science? I think it integrates it a lot because we are saying this syllabus is the same as things we do in everyday. Like that it means where children learn things in class that are applied, whether being modern technology or intermediate one. If you learn something and see how it is applied then that is where technology is working, it does not matter the level at which it is (Jake H.S. 21-04-2004).

As a result of their perceptions regarding the integration of science and technology, teacher's approach to teaching was mainly technology-as-an-illustration approach. For example, the following shows how Mr. Jobo approached the teaching of waves. This was towards the end of the topic.

Mr. Jobo: Electromagnetic waves do not need a material to travel. In other words they do not need a solid, liquid or gas to travel. O.K? All electromagnetic waves are transverse. They can move in an empty space, O.K? All electromagnetic waves travel with the same speed, O.K? Electromagnetic wave can travel in an empty space, a vacuum. Now, mechanical waves can be seen or heard; mechanical waves require a material substance to travel through. They need a solid, liquid or a gas. You have seen water waves, if they have to be produced you need water, a rope you need a rope and you need a solid a liquid and a gas. O.K? Now talking about these waves we have said they transfer energy from one place to another. Are waves helpful in a way? In everyday life we have talked about microwaves, radio waves. Are they helpful? Let us talk about microwaves.

Student: Yes sir, we cook with them.

Mr. Jobo: They can transfer sound like ...They can be used in communication. If you want to communicate with somebody far away we can use microwaves. So they are useful. What about radio waves? How are they helpful in our daily life?

Student: Yes sir.

Mr Jobo: How are they helpful?

Student: If I am at Thaba-Tseka (a place in the mountains of Lesotho) and there is satellite I can have Radio Lesotho.

Mr. Jobo: You can hear the news which is broadcasted in Maseru and you are at Thaba-Tseka (25/08/04, Jake H.S.).

Mr. Jobo started first by teaching the science content associated with waves. Towards the end of the topic he summarised the scientific content on waves and then discussed the everyday applications of waves. Mr. Jobo treated the applications in a very similar way to the textbook (refer to Section 5.2.5. He did not dwell much on the scientific content relating to waves. Similarly, he treated the applications of waves in a superficial manner. In this way learners were not likely to acquire both scientific and technological knowledge and skills associated with the technological artefacts he was dealing with. He used the example of microwave and the radio to illustrate how waves are used in everyday life.

In another case Lineo the science teacher at Lelimo High School declared at the beginning of the class that she was going to start first by treating scientific content on pressure and then dealing with applications. The following is what she said:

Today we are going to investigate some of the properties of fluid pressure and use those to explain some of the things that happen in our daily life. (2/11/04, Lelimo H.S)

This statement indicates that she had planned to cover some aspects of science content on pressure and then move on to the applications. That is exactly what she did. She first started with some activities. The first activity was to show that pressure increases with depth. The second activity demonstrated that pressure at the same level acts equally. She also demonstrated that fluid pressure acts in all directions. She then proceeded with the lesson as follows:

Lineo: Fluid pressure increases with depth of the fluid. Suppose Mr. Thabela has a tank, which collects water, and he has placed the tap at the middle of the tank. What would you say if he complains about the pressure of water from his tap? What would you encourage him to do?

- Student: The pressure increases as the depth increases.
- Student: Madam I would encourage him to move the tap a little lower where it is placed. That is towards the bottom tank.
- Lineo: Why would you do that?
- Student: Because madam pressure increases with depth so if he places it lower there will be more pressure.
- Student: Madam I would put it even lower than where she has put it.
- Lineo: Sabila why do you choose this point?
- Sabila: I will put it further down. I would like to change.
- Lineo: I would like to put it at the bottom of the tank. I would use the pump.
- Lineo: Where is the tank?
- Student: It is on the stand, and putting it underneath.
- Lineo: How will you open the tap?
- Student: I will use a long pump (2/11/04, Lelimo H.S.)

In this discussion Lineo used technology-as-an-illustration approach. Unlike Mr. Jobo she related the technological applications with the science content that she was teaching. Technology was therefore serving as the everyday life context. The results presented above further illustrated that the level of treatment of the technological application was different from one teacher to the next. Earlier Mr. Jobo just mentioned the technological artefacts but Lineo related the scientific content to the technological application she was teaching.

The question which Lineo asked her learners was based on the 2003 examination question on technology which has been analysed in Section 5.2.6. This illustrated that examinations have an influence on what goes on in the classroom. This is in line with the view that examinations turn to be “magnets” to the curricula. As a result teachers tend to teach to examinations. The result is usually a measurement-driven curriculum (Gipps, 1998).

In brief the science educators who participated in the study (teachers, heads of science departments and district science advisors) perceived the science curriculum to be advocating for two elements which are: the acquisition of scientific knowledge and skills and the development of the abilities to apply science in everyday life. Teachers believed that technology was the everyday life context upon which science could be applied. Teachers

therefore used technology-as-an-illustration approach in teaching science integrated with technology. However, teachers did not treat the applications in the same details. In some cases they mentioned the artefacts and in some instances they related the artefacts to the scientific concepts and principles they were teaching.

5.4.4 Teacher preparation

Pre-service education in Lesotho is the responsibility of the National University of Lesotho (NUL) and the Lesotho College of Education (LCE). In trying to establish whether there were any teacher training opportunities to help teachers with the new science syllabus, two science trainers were interviewed. The interviewed science education lectures were from the two institutions mentioned. They indicated that they did not have specific courses for secondary science education. Their courses were mainly targeting 'O'Level which is senior secondary. In concrete terms, there were no pre-service courses geared towards the new syllabus.

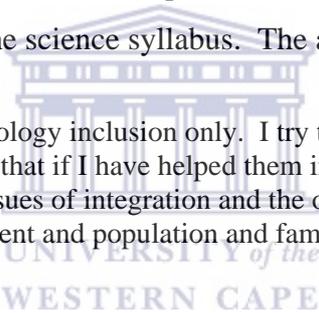
As far as in-service was concerned both NUL and LCE relied on the Induction Programme. This programme is based in the Department of Science Education at NUL. The main aim of this programme is to coordinate in-service courses for beginning teachers. According to one of the science teacher trainers responsible for the Induction Programme, the Induction Programme is not meant for science education in-service courses. In the following excerpt she discussed the functions of the Induction Programme during our interview:

The in-service work that I do at NUL is concerned with inducting new teachers who have just joined the teaching profession. We help new teachers with ideas and issues relating to practice. We give them ideas regarding professional development. This is where we try to bridge the gap between theory and practice. In their workshops we talk about the education system. This is where we bring different representatives of different departments to come and talk to the beginning teachers about the roles of their departments. This is where we make them aware of the function units in our education system. There are also other people that we invite to these workshops who are not necessarily in the education departments. This is meant to help them recognise that there are other things. We try to help them grow in all respects. We invite people to talk about things such as HIV aids and sports because sports are there at school (18/05/05)

The Induction Programme which science teacher educators relied on for in-service training was not targeting science teachers as indicated in the above quotation. However, the Central Inspectorate, a department in the Ministry of Education was assumed to be responsible for conducting in-service training for teachers.

The Ministry of Education (MoE) science inspector and the district science advisors were responsible for guiding and supporting science teachers during the curriculum implementation phase. Although the researcher expected the science inspector to work exclusively with science teachers, the inspector indicated that this was not the case. She stated that her work was not specific to science although during school inspection she may be required to focus on science. (TED 2 19. 5.20050). This therefore, suggests that the science inspector did not directly support science teachers in implementing the new syllabus.

As indicated in Section 5.2.7, the MoE also had four district science advisors who worked with the science inspector. They were responsible for in-service work related specifically to science (DRA 1.15 6.2005, DRA 2.15 6.2005, DRA 3.15 6.2005). One of the District science advisors was responsible for all the schools in the study. During the interviews with this advisor he indicated that he did not deal with the inclusion of technology on its own during in-service. He helped teachers with the understanding of learning outcomes. He believed that understanding the learning outcomes would help teachers include all issues that were expected to be incorporated into the science syllabus. The adviser said;



I do not concentrate on technology inclusion only. I try to help them understand the learning outcomes. I believe that if I have helped them in this regard I will have helped them to address the issues of integration and the objectives dealing with that. That is technology, environment and population and family life issues (DRA 1.15 6.2005).

This indicated that even where teachers worked with the advisor they never got to deal with the issue of technology inclusion specifically. Furthermore, the advisor emphasised learning outcomes. As a result the advisor did not guide teachers in understanding the objectives of the science curriculum. From the interviews with both the in-service and the pre-service providers it was evident that teachers did not have any support relating specifically to the integration of science and technology.

Teachers confirmed the assumption above during our interviews. The following is what the teacher at Jake High School said during our interview:

Researcher: Do you get support from the Ministry of Education?

Mr. Jobo: Inspectors do not come here.

Researcher: Do you attend in-service workshops organized by the Ministry of Education at district level?

Mr. Jobo: We stopped attending them. When we got to the workshops we found that the attendance was poor. The workshops were not organized and the things we did there were not helpful to us. We used to set common papers and they had many errors (5.04.2005 Jake H.S).

Other teachers also showed concern with regard to lack of support in implementing the science-technology curriculum. The excerpt below illustrates Maria's dissatisfaction about lack of support:

Third concern is that like where I taught before the science resource person (District Science Advisors) would come or call us to the resource centre to discuss with other people. You do not get any help from the Ministry of Education or from the Curriculum Center. Basically you are on your own. You are to interpret the syllabus; you are to know what to do, which is not proper (8/05/04 Metheleng, H.S)

All teachers in the case schools voiced lack of support by the Ministry of Education in the implementation of the science curriculum. Although the Lesotho education system had structures in place for supporting curriculum implementation, teachers still lacked support in the implementing the new science syllabus. As such the incorporation of technology in the syllabus was left to the teachers to implement.

5.4.5 Arrangement of lessons

As indicated in Section 5.4.2, all the case schools had six science periods per week, which were arranged in double lessons. Each double period lesson lasted eighty minutes. However Metheleng High School was the only school where the science teacher taught all the science subjects. The other three case schools had adapted what was referred to as the subject teaching system. In this system teachers taught only subjects that they had specialised in. That is, the physics specialist in the school taught physics, likewise the chemistry and the biology teachers were specialists in their subjects and taught them.

The Lesotho science-technology curriculum strived for integration. On the contrary the science curriculum had separated the science subject into biology, physics and chemistry. These made it possible for teachers to separate the sciences in the timetable and when teaching. Furthermore, the pre-services courses separated the science such that teachers were specialists in one or two of the science subjects. Consequently, teachers were comfortable dealing with their own area of

specialisation. The separation of the sciences was observed by the researcher to be a deterrent to the goals of the integrated curriculum.

In explaining why they had separated the science subjects, one of the heads of departments in schools which had separated the science subjects indicated that teachers performed better when they are teaching their specialisation. In response to why they had separated the science subjects The Head of Science Department at Jake High school responded as follows:

When I came to the school it was already done. However, it is the attitudes of teachers to teach more and better on subjects that they have specialized in, so in that case we were trying to solve the problem of say someone has majored in physics and mathematics and you find that he continues to teach physics only leaving chemistry and biology out. He might give them little attention since this is where his interest is... (Jake H.S. 21-04-2004)

The issue of adapting the subject system in the school seemed to work against the integration of technology into science. In trying to incorporate technology, teachers were sometimes challenged to cross to other science subjects. However, where the sciences were separated teachers were reluctant to move beyond the subject they were teaching. The quotation below illustrates the case of the teacher who was reluctant to deal with content in other subjects:

Mr Jobo: If our eyes are not perfect so are our ears. In other words, although you can hear some sound, there are some sounds which you can not hear. But they are still there. Such sounds are called ultra sound. So you can not hear ultra sound, but certain animals can hear ultra sound. So, there are some sounds that you can not hear. Just like there are some things you can not see. In other words although you can hear mechanical waves there are those that you can not hear. That means they are beyond the limit of being detected by your ears. Just like you use the microscope to see things you can not see with your eyes. Is it your first time to hear the word ultra sound?

Learners in chorus: Yes, others No.

Mr. Jobo: Some of you say No. Where have you heard about ultrasound.

Learners: In Biology.

Mr. Jobo: What were you talking about?

Student: We were talking about instruments.

Mr. Jobo: What do you know about ultrasound?

Student: Our Biology teacher said ultrasound is the sound that we can not hear with our ears.

Mr. Jobo: Ultrasound?

Student: Yes sir, the instrument which helps us to hear sounds we can not hear is the stethoscope (25/08/04).

Mr. Jobo did not expect the learners to have learned ultra sound in biology. It can be assumed that is why he asked (ultrasound?). As he continued with his lesson he did not bother to relate the ultrasound that he was talking about to that the learners brought from biology. He did not refer to the stethoscope since this was done in biology. This can be a problem as explanations of technological applications can sometimes draw content from different science disciplines (Fensham, 1988).

At Lelimo High School, Lineo was also challenged to include content from other science subjects when teaching the electric cell. In order to explain the working of the cell she needed some chemistry concepts. She decided to tell learners that this will be explained when they have done atomic structure. She said “the carbon rod is an electrode. For any cell to function you need two electrodes. I will be able to explain to you better when you have done the atomic structure in chemistry. Please remind me (31/08/2004 Lelimo H.S.)”.

Learners’ questions around technological applications were not restricted to one science subject or to the learning outcome that the teachers wanted to pursue at the time. As a result separating the science in the syllabus and when teaching can work against the spirit of integration.

In brief, three of the four case schools had separated the science subjects on the timetable and when teaching. The assumption is that teacher training which encourages specialisation and the syllabus arrangement which had also separated the science subject encouraged the teachers’ practice in this regard. However, teachers in their attempt to incorporate technology into science were challenged to draw content from all the science subjects. As observed in this study separating the science subjects in teaching seemed to contribute negatively to the goal of integrating science and technology.

5.4.6 Learners’ background knowledge

All the learners in the four case schools were in the first year of secondary education. They had all passed the Primary School Leaving Examinations. However, Lelimo High School admitted mostly first class learners. As indicated in Section 5.4.2, learners in this school were supposed have good background knowledge in most

subjects. This was observable during the classroom observations. The level of discussion between the teachers and the students was high. Learners also asked questions which challenged their teacher. Below is the discussion which the teacher at Lelimo High School had with the learners on the sources of electrical energy.

- Lineo: So we are left with chemicals, sun, air and lightning to discuss. Let us discuss the chemicals.
- Student: I think there are chemicals in the battery.
- Lineo: Which batteries?
- Student: The car battery and the small batteries as well.
- Lineo: The sun. What about the sun.
- Student: We put the solar panel in the sun and we get electricity.
- Lineo: So we use solar energy, agreed?
- Lineo: Air?
- Student: Air behaves like water in turning the turbine or something like the turbine.
- Lineo: So it still needs a generator. So the source of electricity is the generator. So basically we have the sources of electrical energy: battery, solar energy, power station including hydro power station, generator.
- Student: How about lightning?
- Lineo: How about lightning? Is it a source of electricity? For the moment we do not take lightning as the source of electricity and we leave that one out (3/08/04 Lelimo, H.S.).

In this lesson the teacher was not the only one who asked questions neither was she the only one who put forward a point to be discussed. This type of discussion was typical at Lelimo High School. However, in other cases learners did not easily engage in a discussion with their teachers. The following excerpt is a lesson on a similar concept as above being dealt with at Jake High School.

- Mr. Jobo: We will be doing electricity today. What is electricity?
- Student: It is the form of energy.
- Mr. Jobo: Electricity is a form of energy. What are the sources of electricity?
- Student: water.

Mr. Jobo: yes.

Student: wind.

Mr. Jobo: yes.

Student: acids.

Mr. Jobo: next.

Student: magnets.

Mr. Jobo: no.

Student: batteries.

Student: lightning.

Mr. Jobo: no.

Student: solar.

Mr. Jobo: yes.

Student: generator.

Mr. Jobo: Ok .We will be focusing on batteries and generators as sources of electricity.

Mr. Jobo: What is a battery?

Student: It's anything that has positive and negative (the student was reading it from the textbook)

Student: a battery can be recharged and a cell can not be recharged

Mr. Jobo: some cells can be recharged.

Student: The battery is the number of cells, more than one connected together (again reading from the textbook).

Mr. Jobo: A battery can be made by connecting two or more cells together (21/04/04), Jake H.S)

This type of behaviour whereby students use the textbook to respond to the teachers' questions was very familiar at Jake High School. The learners hardly responded to questions without referring to the book. This made lessons to be dull.

Teachers in the study believed that the science-technology curriculum required them to teach science and then use technological artefacts and issues as applications. This understanding implied that teachers had to teach some science content first. Then proceed to deal with

applications. This did not easily happen where learners had poor science background knowledge and lacked experience with artefacts. It was difficult for some learners to understand basic science content. Consequently it became difficult for teachers to deal with applications. For example, Mr. Sofonia decided to postpone some content on electricity because he believed that his learners did not have enough content and experience to deal with some content areas in electricity. His argument for moving the Form A (grade 8) content into Form B (grade 9) was as follows:

Researcher: Sir, when are you going to do electrical hazards and wiring the pin plug?

Mr. Sofonia: In Form B under the topic electricity and magnetism. This is in Book 2. Electrical hazards are done in Form B because they (learners) have not done current electricity. We do it when we do current electricity.

Researcher: What are the reasons for this?

Mr. Sofonia: Suppose we do it now, they will have not done current electricity and this is in Form B. They lack knowledge of current electricity and this makes it difficult for them to understand this. It is like how the wires are connected in the plug or that they have to switch off current when they plug something they will not understand, especially those who do not have electricity at home. In Form B we start first by current electricity so that those who have no electricity can understand.

UNIVERSITY of the

Mr. Sofonia was aware that some of his students had not experienced electricity. He decided to teach electrical hazards and wiring the pin plug when learners have been introduced to current electricity. In another school where learners had experienced electricity, dealing with these topics was not a problem. The teachers were quite aware of the role played by background knowledge in their teaching. Mr. Jobo believed that it was important to start with the basic scientific knowledge or otherwise the learners would not follow what is being delivered in the lesson. He thought the basic knowledge was determined by the learners' background knowledge. When asked how he decided on what was basic knowledge for his learners, he said:

It depends on the learners; I think you saw my class. I was in most cases talking to the few learners, five or four boys only. Sometimes I was wandering if I was not doing things on my own (5/04/05 Jake H.S.).

In short the discussion above suggests that background knowledge determines how far the teacher can extend his lesson. Where students have insufficient pre-knowledge of

concepts and lack of experience with artefacts it was difficult for the teacher to reach the application level.

5.4.7 Mismatch between the syllabus and the

It is acknowledged that textbooks are not necessarily written for a specific syllabus. However textbooks help teachers who do not have adequate content knowledge (Sjoberg & Jorde, 1995). According to the science inspector in Lesotho, some teachers, especially unqualified teachers neglected the syllabus and used the textbooks as a curriculum guide. As a result textbooks dictated the content and approaches to teaching. In the case of Lesotho it has been a custom to write science textbooks which attempted to address the demands of a particular syllabus. Where textbooks were supposed to serve the described purpose the subject panel members were commissioned to write such textbooks. Science teachers in Lesotho were therefore used to the textbook which illustrated the demands of the syllabus. The analysis of the science syllabus (Section 5.2.4) and the textbook (Section 5.2.5) showed that there was a mismatch between the textbook and the syllabus. This mismatch seemed to confused teachers and heads of science departments. The heads of science departments alluded to this as the main problem with the new syllabus. During our interview when asked to comment about the syllabus the head of science department at Metheleng High School said:

It is still O.K. but the only problem which I think is there is the way the topics are arranged in the syllabus as compared to the way they are arranged in the book. Say for example, Nutrition would be put in the syllabus such that you have to teach this and that. But then when you go into the book you find just a bit of that topic under bigger brought chapter and find other bits in the other chapters. I find the problem to be that other teachers would just look at the syllabus and find that he/she had to teach Nutrition. He would then move to the book to teach Nutrition following the book and takes the whole chapter. Sometimes he or she leaves some bits of nutrition. I noticed that last year. Mr. K. was still here. But Mr. K , but remember that because last year I acted as the Head of Department when Mr.K. was sick and on sick leave. Some teacher had a problem of just looking in the syllabus for the topic. The syllabus approach is different from the textbook (Metheleng H.S. 8/05/2004).

The mismatch between the textbook and the syllabus was a problem. Mr. Jobo believed that a good textbook for the new science syllabus would demonstrate to them how to teach the new syllabus and could support learners who did not have science teachers. The teachers felt this mismatch was a hindrance to the implementation of the syllabus. This is what Mr. Jobo said about the textbook:

I think it is ok but we thought that if the syllabus is like this then the textbook would help us teach the syllabus. The syllabus is not inline with the textbook. Some children do not have a teacher and the good textbook could help them. I do not know who should tell us about the reforms in the syllabus (Jake H.S. 5.04.2004).

Except the heads of departments at Jake High School and Lelimo High School all the teachers regarded the mismatch between the syllabus and the textbook to be a problem.

5.4.8 Summary

In summary, the results of the study suggest that teachers viewed technology as the everyday life context upon which they could apply science. As a result of this understanding they often used technology-as-an-illustration approach in teaching.

The results of the study indicate that there were no teacher training efforts geared towards guiding teachers in implementing the Lesotho science-technology curriculum. This suggests that teachers' perception of the incorporation of science and technology was based on the common understandings that science educators generally have about the relationship between science and technology (Gardner, 1994; Cajas 1999). As indicated in Chapter Two, the motivation for technology under this conception is to use technological applications to enhance understanding of scientific content and principles. This view of technology is limited as an approach to technology education since it neglects design skills which are central to technology education.

Furthermore, it was found that teachers in three out of the four schools in the study had separated the sciences into biology, physics and chemistry on the timetable and when teaching. However, in dealing with technological applications teachers were challenged to use content from other science subjects which they were not teaching. This was not surprising since technological applications by their nature require content from different subject areas (Fensham, 1988; Solomon, 1988). Separating the sciences was therefore a hindrance to integration.

As indicated in the preceding paragraphs, the results of the study show that teachers favoured technology-as-an illustration approach. In using this approach teachers started by teaching science content and then applied the science content in everyday life context. Where learners did not understand the basic science content it was difficult for teachers to deal with applications. Similarly where learners did not have experience with certain artefacts or issues

in technology it was difficult for teachers to treat them in class. Learners' background knowledge therefore played an important role in determining the level of integration of technology into science.

Although it was not fully established how the textbook interfered with the incorporation of technology, it was found that teachers regarded the mismatch between the textbook and the syllabus as a problem. In brief the antecedents which were found to exist in the case schools were teachers' perception of technology, lessons arrangement, teacher preparation, learners' background knowledge and a mismatch between the syllabus and the textbook.

5.5 Transactions

5.5.1 Introduction

Given the antecedents which have been discussed in the previous section, the aim of this section is to discuss the findings of the study that relates to transactions which took place between teachers, the learners, the materials and the learning environment in the schools. In specific terms this section reports on what teachers did in trying to implement the plan of the curriculum developer under the conditions which exist at school level as discussed in the previous section. The classroom observations in the study focused on three physics topics, which are pressure, electricity and waves.

5.5.2 Levels of incorporating technology

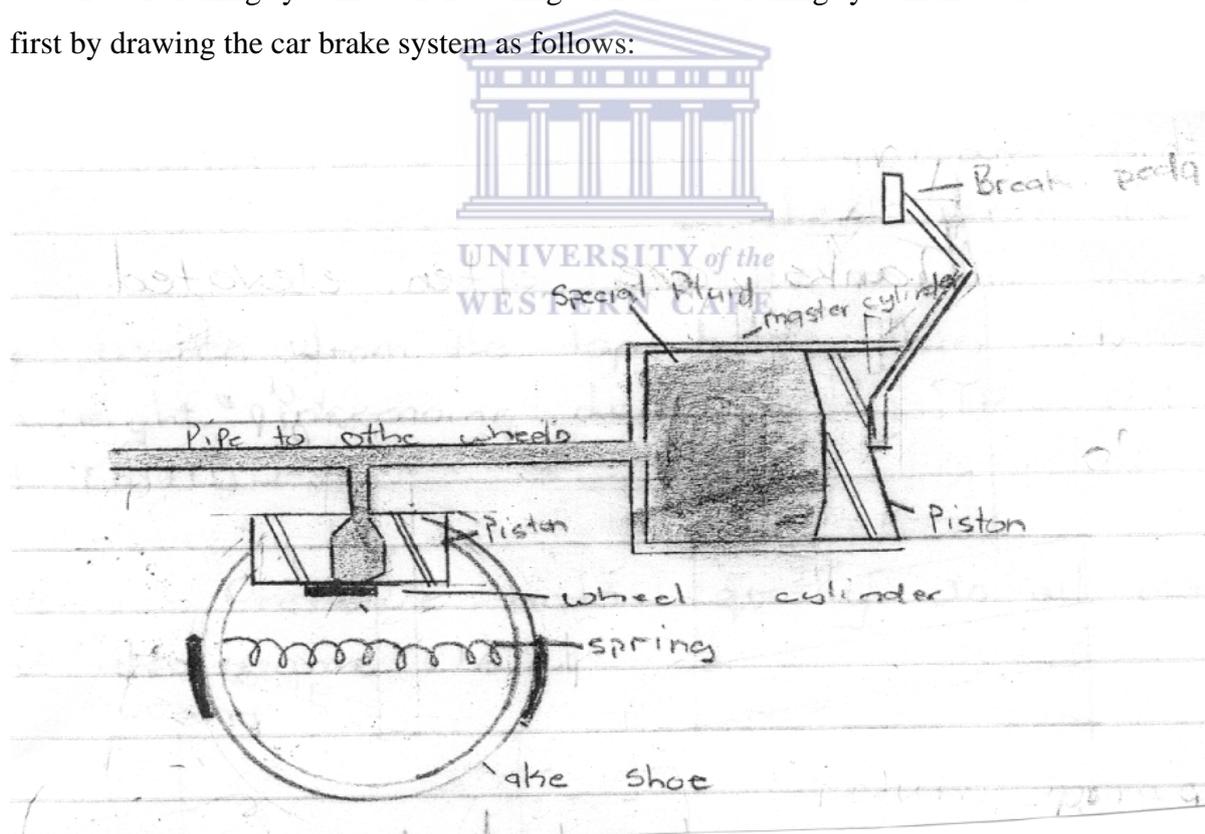
As pointed out in Section 5.4, teachers in the study perceived the science syllabus as a syllabus that attempts to apply science in everyday life. In their lessons they tried to use technological applications as much as possible. However the level of application varied in terms of depth. In some instances teachers just mentioned technological artefacts. Take for instance when the teacher said “things which use electrical energy are called appliances. For example radios, the kettle, the TV and so on are appliances” (21/04/2004, Jake H.S.). This illustrates the case of incorporating technology where the teacher was just mentioning the artefacts.

In some instances the teachers related the technological application to the science content they were teaching. As Maria was teaching pressure she brought diagrams of different applications on the concept of pressure. After she had introduced pressure as a scientific concept she then discussed its applications briefly. Part of her discussion was as follows:

On the diagrams, diagrams 1 to 5 are on suction pressure. Diagram 6 shows air above water, pressing water, the water is pressing on the man. In diagram 7 the air is pressing on the boat. It is not pressing enough so the boat is not sinking. The man is wearing a diving suit, which have hard skin. The pressure of air is acting on him from all directions and the suit prevents him from collapsing like the bottle. Diagram 8 is the diagram of the hot air balloon, the hot air is pushing on the balloon and the balloon remains inflated (23/04/2004 Metheleng H.S.)

In the above quotation Maria was trying to integrate technology as well. She used diagrams to illustrate technological artefacts. There is an attempt to relate the artefacts to the science content that she was teaching. But this was superficial.

In some cases, teachers related parts to the working of the artefacts. However, the artefacts were dealt with because they were application of the scientific principle or content they were teaching at the time. During the teaching of pressure Lineo started by introducing pressure as a scientific concept. She then went on to the applications later in the topic. One of her examples of applications of pressure in everyday life was the car braking system. When dealing with the car braking system she started first by drawing the car brake system as follows:



(3/11/04 Lelimo H.S student notebook)

She then discussed the working of the different parts as follows:

Lineo: Uuuh! So we are going to learn what happens when they step on the brake pedal. What happens such that the car ends up stopping? So this is the brake pedal. Do we see it (Pointing at pedal on the diagram)? What happens when you step on the pedal? In which direction does it move? (3/11/04 Lelimo H.S.)

Some learners said upwards and others said forward

Lineo: Hei! Hei! It goes this way, because you step on forward like that. When it moves forward like that it pushes on the piston. Then we have this special fluid and this is where it moves. Then when you press on the piston it puts pressure on the piston. And then that pressure gets transmitted throughout the wheel. We are still together, not so? (3/11/04 Lelimo H.S.)

In the above discussion Lineo was dealing with a technological artefact - the car braking system. She focused on the parts and functions of the different parts. The level of application here was different from when just mentioning the artefact. She was not just saying pressure is used in the car brake system. There was an attempt to make students aware of how the car braking system works and how it uses a scientific concept of pressure.

The above quotations illustrate how teachers tend to focus on science content when teaching about technology. As a result technology was used as an illustration of scientific principles and concepts. In turn, this type of teaching might in the long run leave pupils with the impression of technology as simply the application of science. However the level of treating the applications was different. In some cases the teachers just mentioned the technological application, in other cases they related the technological artefact with the scientific concept being dealt with, while in some instances they actually dealt with the parts and functions of the artefacts. Even where they went into the details of the working of the technological application, they still used the artefacts to illustrate the scientific concepts and principles. It could be assumed that teachers treated the artefacts at different levels of abstraction because they were not sure of the scope of treatment of technological applications. It is also possible that the level of treatment of different technological artefacts was determined by learners' pre-knowledge as indicated in the preceding sections.

5.5.3 The scope and sequence and learning outcomes

As indicated in Section 1 the science syllabus was arranged such that it had objectives and learning outcomes and the learning outcomes were arranged according to subjects and level. It was found that teachers in the study relied more on the learning outcomes than the general objectives. Consequently the learning outcomes dictated depth of treatment of scientific

concepts and technological applications. When asked what she thought of the depth of the syllabus Lineo commented as follows:

Depth no, I think it needs to be broadened. Like I was saying I wish we could have more time to explore a topic such that you do not only treat the learning outcome in class. One learning outcome, sometimes when you look at it critically you find that you could come up with many specific learning outcomes which could end up with more lessons. You end up saying if I give them the idea here they will still have the expected outcome, but at the end it does not give a student a chance to explore what is happening around the learning outcome (14/09/2004, Lelimo H.S).

This suggests that Lineo relied on the learning outcomes for preparing her lessons. As indicated in the Section 5.2.4 these were the intended learning outcomes (ILOs), which were stated in specific behavioural terms. Based on the quotation it could be assumed that she equated one ILO to a lesson. To her, ILOs dictated concepts and skills that learners needed to acquire. However, she was aware of their limitations in relation to describing the expected learning experience for her learners.

Although teachers relied on ILOs, there was evidence to suggest that those related to technological applications did not clearly stipulate the type of competencies that learners needed to attain. For instance, one of the learning outcomes on pressure read: “describe the applications of pressure in everyday life” (Ministry of Education and Manpower Development, 2002: 18). This ILO is likely to be interpreted in different ways. As a result of ILOs like this, it could be assumed that teachers in the study did not interpret ILOs related to technological applications in the same manner. Consequently, they treated the technological applications differently. Hence, in some cases teachers gave examples of artefacts, in other instances they related the artefacts to the science content they were teaching and at times they described the working of the artefacts describing parts and functions. It can therefore be assumed that ILOs failed to describe the scope of treatment of technological applications.

Teachers supported this assumption. This is what Lineo said in relation to her inability to establish the depth at which she had to treat some aspects of the syllabus.

It used to challenge me but I am now comfortable, it used to challenge me in the way of finding out how to apply things in everyday life. Again the problem is depth. That how far should I go with the learning outcome? A particular learning outcome, to what level should I treat it (14/09/2004, Lelimo H. S.).

From the above quotation it is evident that Lineo's problem is related to scope. That is the scope of treatment of applications. She was comfortable with treating application but the ILOs did not show how detailed she should treat the applications.

Another challenge related to sequencing of ILOs. In some cases the ILOs associated with technological applications required detailed science content in order to deal with them. For example in dealing with the three pin plug and relating the earth wire to earthing appliances it seemed teachers needed more content to explain this to learners than the content suggested in the Form A science syllabus. The Form A science syllabus ILOs for electricity were:

- describe the structure of a simple electrical cell
- identify types of electrical cells
- illustrate simple circuits
- identify electrical hazards
- connect a 3-pin plug
- state safety precautions associated with electricity (Ministry of Education, 2002:21)

The safety precautions that teachers actually dealt with included earthing and use of the fuse and the three-pin plug. These are technological applications. In dealing with the three-pin plug teachers did not only ask learners to connect the three-pin plug, but they also dealt with colour coding in the wires, the earth pin and its functions, and related the earth pin with earthing appliances and the fuse (Metheleng H. S 14/09/04). The following were the notes that Maria gave to her class when she taught safety precautions.

Mains Electricity

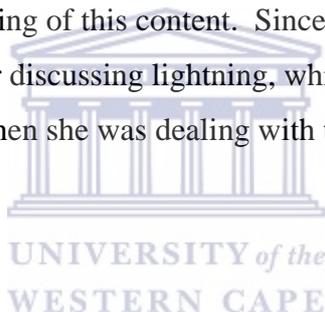
Mains electricity comes from the power station. It can also be produced in a generator. The power stations produce electricity from coal, nuclear reaction (South Africa) or water in hydroelectric dams. The power is then conveyed to the homes, schools and factories by high voltage wires. The mains electricity is alternating current. The mains electricity in Lesotho is 240v. The high voltage is dangerous. Insulating material must protect the wires that connect power from the poles to the houses. All wires inside the house must also be insulated mainly by plastic. All appliances using electricity must be earthed to carry excess current away from the appliances. For example, an electric kettle is connected to the mains by the three-pin plug. The big pin on the plug connects to the big hole on the wall socket, which is connected to the earthing wire. The big pin on the plug is connected to the kettle by a green wire called earth. Some three pin plugs also include a fuse made of a thin wire. This fuse "blows" by melting when excess current passes through it, protecting the electric equipment (14/09/04, Metheleng H.S)

The notes show the details Maria focused on in treating electricity and specifically safety precautions. These details are not necessarily specified in the Form A ILOs. In order to get to the details, teachers needed more content than that suggested by the Form A (grade 8) syllabus learning outcomes. The different teachers handled this problem differently. Some teachers deferred the discussion that required them more content than that described by the learning outcomes. For example, this is what Lineo said as she was explaining the sources of electrical energy and confronted with the issue of content that she has not covered or may not be covered in Form A (grade 8). Lightning appears in Form B (grade 10) under electrostatics:

Student: How about lightning?

Lineo: How about lightning? Is it a source of electricity? For the moment we do not take lightning as a source of electricity and we leave that one out (03/08/2004, Lelimo H. S.)

The researcher believes that the teacher did not want to deal with lightning because she would be going into electrostatics. Electrostatics was supposed to be taught in Form B (grade 9). She therefore postponed the teaching of this content. Since this question was from the learner this was an opportune moment for discussing lightning, which is part of the electricity content. Another example was when she was dealing with the three-pin plug and relating the earth pin with earthing.



Lineo: What is the earth wire? What do we mean by earthing? What is the importance of earthing?

There was silence ...

Lineo: Maybe we should leave this one we will talk about it sometime, so we should use appliances which have earth wire or which are earthed. What else can electricity do? (31/08/2004, Lelimo H.S)

The teacher just mentioned the earth wire. She was still focusing on the Form A (grade 8) learning outcomes but since this application demanded her to go beyond the Form A syllabus learning outcomes, she decided to just mention the issue of earthing appliances. If she went further she might have been required to deal with issues such as wiring a house, what is meant by earthing and so on.

In a similar manner Mr Sofonia at Sofy High School decided that he would not treat the wiring of the three pin plug and the electrical hazards until he had covered enough electricity

for learners to understand what wiring a plug involves. He therefore moved this content to the next year (24/08/04 Sofy H.S).

In dealing with the same problem of ILOs sequencing some teachers rearranged the content such that it could allow them to handle the applications easily. In other cases the teacher decided to bring all the content for the three levels that is Form A (grade 8), B (grade 9), and C (grade 10) together. Maria brought all the content from other levels on electrical circuits to Form A, so that later she could deal with applications of circuits such as the three-pin plug, the fuse and earthing appliances (14/09/04 Metheleng H. S.). For a similar reason Mr. Jobo taught all the content on waves in Form A before he could deal with applications on waves.

As indicated by Ornstein & Hunkins (2004) sequencing can be based on different educational understandings such as simple to complex learning. Rearranging content sequence worked against such understandings. It is acknowledged that teachers may rearrange content sequence in the syllabus in order to suite their teaching styles. This might have been the case in this study but it was a bit extreme since they were not rearranging the syllabus sequence across one grade. In the case where content is moved from higher grades to lower grades it can overload learners and create content vacuum in the higher grades. However, the researcher assumed that teachers saw the need to rework the science content so that it could help them to describe and explain some technological applications (Layton, 1993).

The issue of lack of science content to support explanations of some technological applications also restricted teachers in dealing with applications which were of interest to the learners. In the following discussion between Lineo and her learners, she had requested learners to give examples of sources of electrical energy.

- Student: Another one is petrol.
- Lineo: Can you explain how petrol produces electricity?
- Student: The generator can not work without petrol.
- Lineo: So you still need the generator to produce electricity. Without going into detail of how it uses petrol we can see that petrol, water and turbine all need a generator and the generator is the one, which produces electricity (03/08/2004, Lelimo H. S.).

Lineo wanted students to explain how the generator uses petrol to produce electricity. Yet Lineo avoided the explanation. She avoided the explanation and indicated that the turbine, water and petrol need a generator to produce electricity. This may imply that

the generator uses water and petrol in the same way to produce electricity, which is misleading. This is probably because the content required to explain how petrol is used in the generator to produce electrical energy is complex for the level she was teaching. De Vries (2006) argues that the science content required to explain some science and technology innovations is not at the cognitive level of most school going learners. Given that generators which use petrol to produce electricity are common in Lesotho learners could have genuine interest in this issue. The researcher believes the problem lies more with the way content has been arranged in the syllabus. There is a possible explanation at the level of Form A learners. It is just that this is not in the Form A syllabus.

In summary, teachers in the study relied on ILOs for determining the competencies that learners needed to acquire as a result of going through the science-technology syllabus. Hence ILOs dictated the goals of the syllabus. However, they did not adequately suggest the extent to which the technological applications were to be treated. As such individual teachers determined scope of treatment of different applications. In cases where teachers wanted to deal with the applications in detail they were sometimes forced to rearrange the syllabus sequence such that they gave more content to the learners before attempting to deal with the applications. In other cases they deferred the applications to the next level. In her words Lineo summarised the problem they encountered by saying:

I sometimes feel like sometimes the spiral approach has been used even where it is not necessary to have used the spiral approach. Sometimes you end up teaching or giving too little information to the student (Lelimo H.S.14.9.2004).

5.5.4 Diagrams for artefacts

Teachers in the study used diagrams often in their teaching especially when dealing with technological artefacts. In some cases diagrams were used to substitute activities. That is instead of learners doing the activity the teacher would draw the diagram to illustrate the activity. For example, at Jake High School during the teaching of circuits the teacher allowed the learners to connect only one circuit. He then drew diagrams of the rest of the circuits on the board and taught the parallel and series circuits by diagrams. He actually told learners that they would not connect circuits, he said:

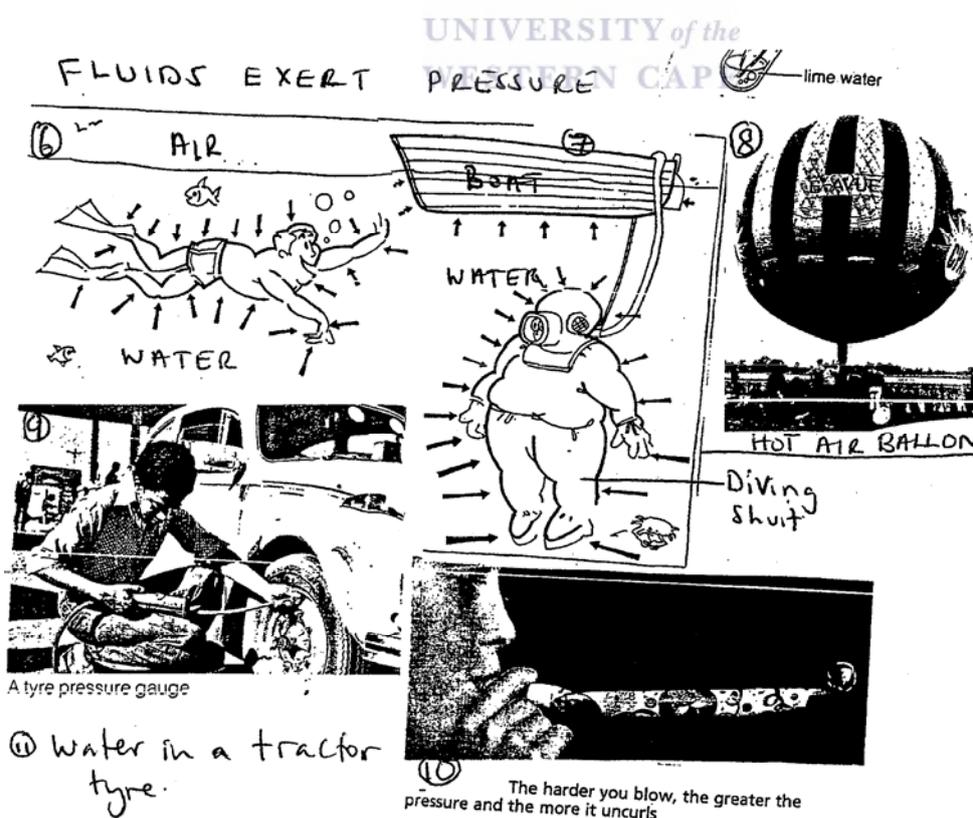
The cells last longer when they are connected in parallel. We are not going to continue doing/making circuits; instead we will draw circuits on the board and discuss them (Jake H.S.27.04.04).

He first drew a circuit on the board, which had two cells in series with one bulb. He then added a third cell and asked learners:

What do you think will happen to the brightness of the cell if I increase the number of cells? (Jake H.S. 27.04.2004)

Most learners were puzzled and stared at the teacher. After some short discussion with learners he then drew a circuit with three cells connected in parallel and asked what will happen to the brightness of the bulb if he added the second bulb. Still learners did not follow. This continued for the entire lesson on connecting circuits. In the previous lesson the teacher had tried to use the apparatus to demonstrate circuits but some bulbs and cells were not working. The teacher might have abandoned experiments because of lack of facilities.

The diagrams were also used to demonstrate the technological applications of some scientific concepts. For example at Metheleng High School Maria brought diagrams of technological artefacts to class and used them as illustrations of the technological applications. She did not discuss in detail how the technological artefact worked but just discussed the artefacts as an example. In one lesson when teaching pressure she introduced the following diagrams.

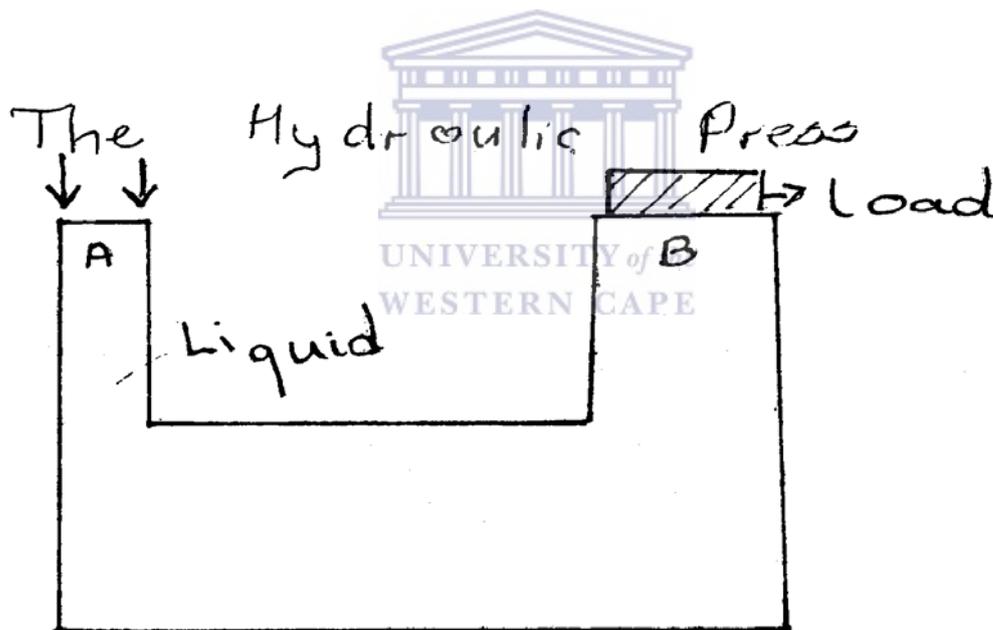


She then mentioned the following:

On the diagrams, diagrams 1 to 5 are on suction pressure. Diagram 6 shows air above water, pressing water, the water is pressing on the man. In diagram 7 the air is pressing on the boat. It is not pressing enough so the boat is not sinking. The man is wearing a diving suit, which has hard skin. The pressure of air is acting on him from all directions and the suit prevents him from collapsing like the bottle. Diagram 8 is the diagram of the hot air balloon, the hot air is pushing on the balloon and the balloon remains inflated (Metheleng H.S. 23.4.2004).

This was still an attempt to incorporate technology. As presented the diagrams did not enhance understanding of concepts or acquisition of scientific and technological skills. They were just examples. However it was not easy for the teacher to get the actual artefacts. In the absence of real artefacts using diagrams was the only approach that the teacher could use.

In other cases teachers attempted to explain the parts and the working of the technological artefact using diagrams. One of the examples that the teacher used under pressure was the hydraulic press. She introduced the artefact by drawing the diagram of the hydraulic press shown:



Lelimo H. S. 3./11/04 (from student's notebook)

She then discussed the working of the artefact with learners as follows:

Lineo: With the hydraulic press you have two cylinders and inside the cylinders there is a fluid. Then this is a disc. Then when you apply pressure on this disc you will apply pressure here on the liquid and this pressure is transmitted through the liquid on to the other end. When it gets here what happens? It is going to lift the disc such that if you have this as your load and you have a heavy object there. What will happen to this thing? Your load, you apply pressure at A and the pressure is transmitted onto B

and what happens? Disc B moves up. And you have placed a heavy load on Disc B. What happens to the load?

Student: The load is also going to move.

Lineo: The load is also going to move up. So here is your disc and it goes up and it comes into contact with the heavy object. What is going to happen to the load?

Student: It is going to go up.

Lineo: Is it going to go up? Remember the load is soft material, what is going to happen to the load?

Student: It is going to be pressed.

Lineo: It is going to be pressed because the load is disc B, B is moving upwards with the load and the load is in contact with the heavy object. It can not move the heavy object. It means it is going to go up and it gets squashed and it becomes small. This principle is used when they are pressing cotton rods into small packages and hence it is called the hydraulic press. Do you have any questions? (3/11/04, Lelimo H. S.)

The diagram can be suitable for the hydraulic lifter as well. The researcher actually thought the teacher was talking about the hydraulic lifter until she said the load is the soft material. Without a real artefact it was difficult to follow this discussion. This further illustrated that in dealing with technological artefacts real artefacts are sometimes required. Diagrams cannot always replace artefacts. In the case of Lesotho where laboratories already lack equipment, the integration of technology with science brings about other complications to the problem of facilities.

In most cases teachers did not have the actual artefacts which they wanted to use as technological applications in their lessons. In order to deal with this problem they used diagrams. In some cases real artefacts were required, especially those that learners had not seen before. As such diagrams did not represent such artefacts adequately.

5.5.5 Use of the textbook

It has already been indicated under the Section 5.4.7, that teachers complained of that the mismatch between the syllabus and the textbook. In all the schools in the study teachers used

the text as a reference for activities. Even during our interviews, teachers indicated that they used the textbook for this purpose. This is what Maria said about the use of the textbook.

Researcher: But normally what do you use the textbook for.

Maria: I use it for the experiments, which are listed. Then I supplement it with other information. The textbook gives the simplified explanation of the concept (8/05/2004, Metheleng H. S.).

Since the activities were taken from the book, learners sometimes used the textbook to respond to the teacher's questions related to the activities. At Jake High School the textbook was used mainly as a reference in class. The learners referred to it when they had problems regarding responding to the teachers' questions on activities. Although teachers complained about the textbook they hardly used the textbook as a reference for any content. Instead they supplemented the book with their notes. As such the book did not seem to be interfering with the incorporation of technology with science in any way.

5.5.6 Summary

The findings of the study suggest that teachers used ILOs to determine content and skills that they had to impart to learners. However, teachers seemed to interpret ILOs related to technological applications differently. As a result they treated the technological applications at different levels of abstraction. This suggested that teachers could not sense the scope of treatment of technological applications.

In dealing with some technological applications teachers rearranged the sequence of content across three grades Form A (grade 8), Form B (grade 9) and Form C (grade 10). They did this by either postponing content or moving content from higher grades to Form A. The researcher assumes that the syllabus sequence did not allow teachers to deal with some technological applications without rearranging the sequence.

Some technological applications required equipment and artefacts which were not available in the conventional science laboratory. The microwave is an example of such an artefact. In the absence of such artefacts teachers used diagrams. The researcher is of the opinion that the diagrams did not represent such artefacts adequately.

5.6 The outcomes

5.6.1 Introduction

The achievement test was administered to the learners in the case school at the end of every topic that was observed. It is only at Sofy High School where such tests were not administered because the teacher transferred most of the content for Form A into Form B. As a result learners could not manage the tests. The aim of the tests was to find out if learners had acquired content and skills in science and technology that the curriculum planned they should develop. The tests focused on electricity, waves and pressure. The results reported here are on electricity. Similar results had been obtained on other topics as well. The outcomes of the science-technology curriculum are, however, not limited to performance. Other outcomes which emerged during the study have also been reported.

5.6.2 The syllabus arrangement

As indicated in Section 5.4.5, the different science subjects were separated in the syllabus. This arrangement encouraged teachers to separate them in the timetable and when teaching. Teachers in three out of the four schools in the study taught their specialisation. This was observed as a hindrance to the incorporation of technology into science. In dealing with technological applications teachers were unable to draw concepts from other subjects that they were not teaching. They would rather postpone the treatment of such an application or ignore it.

5.6.3 The mismatch between the syllabus objectives and learning outcomes

The results of this study as reported in Section 1 suggest that there was a mismatch between the science-technology syllabus statements. The science-technology syllabus objectives advocated STS approach. On the contrary the learning outcomes were inclined towards technology-as-an-illustration approach. It is further indicated in Section 5.5.2 that teachers relied on learning outcomes for the goals of the science curriculum. The learning outcomes which emphasised technology-as-an-illustration approach coupled with teachers' perception of technology as an application (Section 5.4.3) resulted with STS approach being neglected. This suggests that aligning curriculum and assessment would be difficult in this case. The question is which curriculum? Is it the planned curriculum or the actual curriculum? If it is the planned curriculum which is emphasised then any test that measured the performance of

students based on the syllabus objectives would not be valid. Consequently, it can be argued that the Lesotho science-technology curriculum did not achieve its objectives as envisaged.

5.6.4 The syllabus scope

In their attempt to incorporate technology using a technology-as-an-illustration approach, it was found that teachers dealt with the technological applications at different levels of abstraction. The learning outcomes which teachers relied on failed to dictate the depth of treatment of different technological applications used in the lessons. As a result, learners did not experience the same science-technology curriculum in Form A. It is acknowledged that learners from different schools may not experience the same curriculum even if there is an official syllabus that specifies what is to be taught (Graham-Jolly, 2002). However, the learning outcomes in this case seemed to bring the difference in the experienced curriculum. Since teachers continuously searched for what to do with the technological applications, it is possible that learners' experiences were different regarding applications of science in everyday life.

5.6.5 The sequencing of the syllabus

The science syllabus in Lesotho prescribed the learning outcomes for the three years of secondary education, showing those that should be addressed each year. The syllabus content was sequenced using the spiral approach. This approach encourages sequencing and continuity. In this approach, the content area is not treated all at the same time but is spread over the different grades. For example, the topic of electricity is not all taught in Form A; instead, the content is spread over three years of secondary education. Most of the time, teachers did the opposite of what the spiral approach advocated for. They either transferred the learning outcomes associated with some technological application to the higher grades or they moved the learning outcomes from the higher grades to Form A (grade 8). Teachers therefore changed the scope and sequencing of learning outcomes in the syllabus. A common test based on the syllabus objectives would therefore not be a valid measure of the experienced curriculum.

5.6.6 The tests results

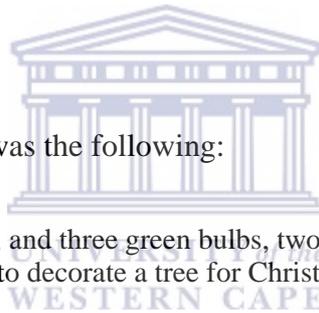
As indicated in Chapter Four, the researcher had developed achievement tests which were administered to students after the teacher had completed the topics: electricity, waves and

pressure. The electricity test was marked out of 19 marks. Seven out of the 19 marks were on the application of science in everyday life, while twelve marks focused on knowledge with understanding. An example of a knowledge item asked in the electricity test was the following:

Mrs Mofolo buys a new kettle and asks you to connect the lead to a three-pin plug. The lead has three wires inside it, each wire is covered with a different plastic insulation. The insulations are green with yellow strips, blue and brown.

- Why are the wires insulated? (1)
- What colour is the earth wire? (1)
- What colour is the live wire? (1)
- Which colour is the neutral wire? (1)
- Which wire is a safety wire? (1)
- Which wire is most dangerous? (1)
- Why is it called the live wire (1)

One of the application questions was the following:



You are given five red bulbs, and three green bulbs, two switches, and two cells and connecting wires. You plan to decorate a tree for Christmas.

Draw a circuit diagram that will allow the following to happen to your light;

The green bulbs should light independent of the red bulbs.

The green bulbs should light all at the same time.

The red bulbs should light all at the same time. (3)

Table 17 shows the average scores on the test as well as on the items at different cognitive levels.

Table 17 Average scores on electricity for three case schools

School	Topic	Overall Mean	Mean on knowledge items	Mean on application items
Metheleng H.S.	Electricity	8.8	4.9	2.8
Lelimo H.S.	Electricity	10.2	6.9	3.0
Jake H.S	Electricity	6.7	4.1	2.1
Sofy H.S.	Electricity	-	-	-

On the whole the performance was not good. Only one school had an average of above 50% and that was Lelimo High School. The learners' performance on applications of science was poor. In all the three schools the average performance on the application questions was below 50%. The results pertaining to the application of science in everyday life are not surprising to the researcher. The learning outcomes which teachers relied on did not specify the competencies that learners need to acquire as a result of dealing with technological applications. Hence teachers treated the technological applications differently. Similarly teachers changed the sequence of learning outcomes. The experiences of learners were therefore different. A common test for the three case schools was therefore not fair.

5.6.7 Summary

The results of this study suggest that there was a mismatch between the syllabus objectives and the learning outcomes. However, teachers relied on the learning outcomes in determining the essential scientific and technological knowledge and skills that they needed to develop in learners. Consequently the objectives of the curriculum which were aligned to STS approach were neglected and the implemented curriculum focused on technology as an application. It can therefore be argued that the objectives of the Lesotho science-technology curriculum were not realised in practice.

Firstly, the findings of this study suggest that separating the science subjects encouraged teachers to separate the science subjects when teaching and this contributed negatively to the goal of integrating science and technology. Secondly, the learning outcomes pertaining to technological applications did not clearly stipulate the competencies that learners needed to acquire as a result of dealing with these applications. On the other hand the spiral approach which was used in developing the science-technology curriculum did not fit well with the

integrated curriculum. As a result teachers modified the learning outcomes sequence. This caused variations in the experienced curriculum.

In the context of this study, it was unfair to have a common test, assessing learners' ability to apply science in everyday life and taking technology as the context. It was inevitable that learners would not perform well. This is because the competences that these learners needed to acquire by using technology in the everyday life context were not clearly defined. There are many technological applications that learners can experience through learning; however, there is need to define the competencies that learners need to acquire as a result of such experience. Otherwise teachers will not know what do with the technological applications, as it has been observed in the case of this study.

Chapter six is the concluding chapter. It summarises answers to the research questions. The chapter further highlights the recommendations which are based on the results of the study. It also puts forward the concluding remarks and suggests questions that have not been answered by the study and/or could be proposed for further research.



6. Discussions and Conclusions

6.1 Introduction

This study has investigated the nature of the planned and the implemented Lesotho science-technology curriculum. The intended curriculum was investigated through the analysis of curriculum materials. The implemented curriculum was investigated by examining the teacher-learner-material and learning environment interactions. The data for the investigation were collected through document analysis, classroom observations, interviews and achievement tests. The research design used in this study was a multiple case study design. Stake's (1967) congruency-contingency model was used in the study to guide the collection and analysis of data. However, other theoretical perspectives have been incorporated to support Stake's model in the analysis of data and these are: Gardner's (1990) approaches to the incorporation of science and technology and some aspects of curriculum theory particularly curriculum development and curriculum evaluation. The constant comparative method (Merriam, 1998) was used in analysing qualitative data.

This chapter provides answers to the research questions which have been presented in Chapter One. It further makes recommendations based on the results obtained from the study. The chapter ends with the concluding remarks and indicates the questions which have not been answered by the study.

6.2 Question 1: The nature of the Lesotho science-technology curriculum

6.2.1 Introduction

Technology inclusion in the school curriculum is being experienced globally. However, the arguments for technology inclusion in the school curriculum are many and varied. These arguments in most cases influence the way technology is included in the school curriculum. In some cases technology is included in the school curriculum as a stand-alone subject. In other instances it is incorporated into other subjects (Gardner, 1994; Gardner, 1999; Layton, 1993; Layton, 1994; Treagust & Rennie, 1993; De Vries, 1994; De Vries, 2006). Where

technology is incorporated with science, there are different approaches, which are adopted. This is the result of different opinions about the relationship between science and technology, and this in turn influences the nature of the science and technology curriculum (Gardner, 1990; Layton 1993). Although the researcher recognises from the literature that there are many science and technology programmes which have been initiated in different countries, Gardner (1990) and Layton (1993) were of the opinion that there are certain approaches, which are common in the incorporation of science and technology. Gardner (1990) suggested: technology-as-an-illustration, cognitive-motivational-approach, technology-as-a-process, technology-as-an-artefact and STS (science, technology and society) as the approaches which are commonly used in incorporating science and technology.

The Lesotho science-technology curriculum strives towards the attainment of a scientifically and technologically literate society. However, this has been difficult to achieve since integrating technology and science seemed a difficult task for the science panel. The Science-technology curriculum through its syllabus objectives depicts an STS approach and the learning outcomes imply technology-as-an-illustration approach. Moreover, science content on its own surfaces more often in all curriculum materials such as the syllabus, the textbook and the JC examinations questions papers. Of the five approaches to the incorporation of science and technology suggested by Gardner (1990), the most commonly encountered approach in the syllabus learning outcomes, the textbook and the JC examinations is technology-as-an-illustration approach. As indicated integrating science and technology does not seem to have been an easy undertaking by the Lesotho science panel. The findings of the study suggest that the particular curriculum design used in Lesotho made it difficult to integrate technology and science in the curriculum.

6.2.2 The science-technology curriculum organisation

The fact that science content is visible in the science and technology curriculum is desirable, since straightforward science content will always be necessary for its own sake and for the understanding of technology (Kelly, 1987). Nonetheless, what becomes a concern is when the curriculum that claims to integrate technology is highly skewed towards the acquisition of science content knowledge and skills. As indicated in the introduction, science content appears more often in all curriculum materials that were analysed. Moreover the approach which surfaces most often in the same curriculum materials is technology-as-an-illustration approach. Technology-as-an-illustration approach is based on the view that technology is the

application of science. According to Gardner (1999) and De Vries (1994), taking technology as the application of science does not contribute to the development of technological capabilities but enhances the acquisition of scientific concepts and principles. In essence, the Lesotho science-technology curriculum is basically a science curriculum that has been improved by incorporating some technological applications which support the teaching and learning of science content. Based on the findings of the study, there are possible explanations for the curriculum not achieving integration of technology in a way that would enable learners to acquire scientific and technological literacy as had been envisaged.

Firstly, the Lesotho science-technology curriculum suggests integration of technology. However, the syllabus has separated the sciences into the disciplines of physics, chemistry and biology. The aspects of technology that relate to the different science subjects were integrated within these subjects. In other words technology that related to biology was integrated with biology; likewise those that related to physics were incorporated into physics and so on. Consequently the technological applications that have been used in the syllabus do not cut across the science subjects. This study confirmed that different technological applications draw content from different subjects (Fensham, 1988; Layton, 1993). As a result separating the sciences is contrary to the plan of integrating science and technology.

Secondly, the scope and sequence chart of the Lesotho science-technology syllabus is based on science content only. The science topics are sequenced according to the different science subjects. It could be assumed that technology was not considered in the sequence.

Sequencing content relates to the issue of arranging content such that it fosters cumulative and continuous learning (Ornstein & Hunkins, 2004). If technology was not visible in the sequence chart, it could be assumed that integration of technology was neglected at this stage of the curriculum development process. This therefore suggests that technology might have been introduced later in the process. The latter would make it difficult for technology to fit well with the science content, since the two disciplines (science and technology) were not brought together from the initial stages of curriculum development.

Nevertheless, the curriculum design in which science content takes priority over technology in the sequence might not be unique to Lesotho. In classifying the courses which follow the STS approach, Fensham (1988) indicated that they could be grouped into three categories which are: science determined, technology determined, and society determined. In describing the programme that follow an STS approach which is science determined, the choice of topic to be studied is based on the sequencing of traditional science topics. The science concepts

and principles remain the same. The depth of treatment of added STS topics would vary and can be optional. It is evident that the science-technology syllabus in Lesotho is science determined.

Despite the fact that there are courses which are science determined the common examples of courses that have adapted the STS approach are thematic in nature. The topics which are selected usually address social needs. An example of such a course is the junior science programme for Botswana (Nganunu, 1988). In a similar manner, Fensham (1997) shows topics such as: health, nutrition and sanitation, ecology, energy use, resources and others as the topics in science education that meet criteria for social relevance. Lesotho has not followed this common strategy for designing the science-technology curriculum.

As observed in this study basing technology on the science sequence can be limiting to teachers. In dealing with some technological applications teachers had to rearrange the content sequence in the three levels of secondary education or to postpone the treatment of such applications to the upper grades. Consequently, the sequence was distorted. According to Stenhouse (1988) the curriculum sequence is based on different understandings in education. Examples of such understandings include: subject logic, Piaget's theory of cognitive development as well as some learning principles. Changing the sequence can work against these principles, especially if teachers are not aware of the logic behind sequencing content.

The syllabus organisation also influenced the textbook which was used as the exemplary curriculum material for teaching the science-technology curriculum. The textbook and syllabus named the topics in different ways. As indicated in Chapter Five, the book chapter names suggested integration. However, the science content within the chapters appeared as indicated in the syllabus. The approach to technology integrated with science that seemed to appear more often in the book was technology-as-an-illustration approach. The textbook therefore did not support the STS approach.

The separation of the sciences in the syllabus was found to be in line with the way teachers arranged their teaching of science in the schools. Three out of the four case schools had arranged science to be taught as separate science disciplines. Teachers referred to this system as the "subject system". In this system three teachers taught science in one class. That is, there was a biology teacher, chemistry teacher and a physics teacher. However, they did not relate the subject system to the syllabus arrangement. They believed that teachers who taught their specialisation were likely to be interested in what they were teaching and likely to

perform well in their teaching. It could be assumed that the syllabus arrangement made it possible for teachers to separate the sciences since they were already separated in the syllabus. If the syllabus had adopted the integrated approach it would have been difficult for teachers to see and treat the sciences as separate subjects.

Separating the sciences made it difficult for technological concepts that cut across the science syllabus to be seen and be treated as such by teachers. As a result, teachers in the study were reluctant to deal with issues that required them to use content from other science subjects that they were not teaching. For example, in dealing with the electrical cell, Lineo did not provide details of how it works. Instead she told learners that they would deal with this after they had covered some chemistry. Given that the objectives for the Lesotho science syllabus advocate the STS approach, this suggests a weakness in this syllabus, since issues in science and technology; especially STS usually involve concepts from different disciplines. Therefore separating the sciences in the syllabus and teaching them as such does not support the curriculum initiative that attempts to incorporate technology and related societal issues.

In summary the Lesotho science-technology curriculum strives for scientific and technological literacy. However, this was not easy to achieve. The findings of the study suggest that the curriculum design adopted by the science panel in developing the science-technology curriculum might have contributed to a lack of success in integrating science and technology. The results of the study show that:

- The science syllabus had separated the science subjects into biology, chemistry and physics. This did not allow technological issues to cut across the science subjects.
- The scope and sequence chart was based on science content only hence neglecting technological knowledge and skills. Consequently teachers had to rearrange the syllabus sequence in attempting to deal with technological applications.
- The exemplary curriculum material (the textbook) used chapter titles which suggested integration but the content remained as in the syllabus.
- Three out of the four schools in the study used the subject system which allowed teachers to teach their own specialisation. As such teachers were reluctant to move beyond their teaching subjects.

6.2.3 The mismatch between the objectives and the learning outcomes

Curriculum perspective

As indicated in Section 6.2.2, the findings of the study show that the Lesotho science-technology syllabus through its objectives advocated an STS approach. However, the syllabus through its learning outcomes focused on technology-as-an-illustration approach and emphasised science content. This suggests that the curriculum through the syllabus communicated two different messages to the curriculum users. The objectives are at a higher level of specificity; in the everyday language they indicate the planned destination. The learning outcomes are at a lower level of specificity and in using a similar language; the learning outcomes indicate how to get to the envisaged destination. Ornstein & Hunkins (1993) indicated that objectives are written for the subject outcomes, and learning outcomes are statements which indicate in precise terms what a student is to learn. They further indicated that the learning outcomes are usually developed by teachers while objectives are designed by curriculum developers. It is not common to come across a mismatch between the statements of curriculum policy in the literature. The literature more often picks up on the issues of the mismatch between policy and practice. A number of curriculum scholars have alluded in their writings to the fact that curriculum studies are about relating the intentions of the curriculum to what actually happens at school level (Stenhouse, 1988; Kelly, 1989; Cornbleth, 1990). In the case of Lesotho as indicated in Chapter Five both objectives and learning outcomes for the Lesotho science curriculum were developed by curriculum developers. The inconsistency between syllabus objectives and the learning outcomes suggest that the learning outcomes and the objectives are not working towards the common goal. This cannot be easily understood in the case where both the objectives and the learning outcomes were developed by the same group of people. However, this inconsistency can be explained in terms of the curriculum perspective hence the curriculum model which was adopted by the science panel in developing the curriculum that incorporates technology.

As indicated in Chapter Five, the process of curriculum development that the science panel carried out in developing the Lesotho science syllabus was hierarchical and sequential in nature. This is demonstrated by the design of the science-technology curriculum in the case of Lesotho which flows from aims to learning outcomes. From this type of curriculum design it can be assumed that the panel members perceived curriculum-as-technology. Hence they viewed the exercise of integrating technology and science as a technical undertaking. This

approach according to Eisner (2002) and Ornstein & Hunkins (1993), concern curriculum planning and they view it as essentially a technical undertaking. Eisner (2004) argues that the nature of the technical perspective is that curriculum developers engaged in it tend to focus more on the process than to rationalise the different components of the process. As a result it can be assumed that the panel did not critically focus on the contents of their product, which is the syllabus. They focused more on the procedure for developing the curriculum. That is as long as the procedure of designing the curriculum was correct it was assumed that the end product would be perfect. The product was not perfect. The mismatch which was found between the science syllabus objectives, which implied a STS approach, and the learning outcomes, which encouraged technology-as-an illustration, provides evidence of this.

The inclusion of technology into science by its nature is complex since there are many views about the reasons for the inclusion of technology in the school curriculum. Furthermore, there are various ways in which science can be incorporated with technology. Moreover, there are different approaches which can be adopted in incorporating science and technology. This therefore requires rational decisions and can not be reduced to a mechanical procedure; otherwise the end product is likely to be different to what was envisaged. Assuming that technology inclusion into science can be reduced to a technical procedure undermines the complexities associated with this curriculum area.

Behavioural objectives

The technical approach to curriculum development is linked to the objective model to curriculum development (Posner, 2002; Eisner, 2004; Eisner, 1985; Stenhouse; 1988). The debate around the issue of behavioural objectives is well documented in the literature. Eisner and Posner have written elaborately on this issue and have suggested alternative ways of writing objectives. Eisner (2004) argues that the limitation of this way of thinking about curriculum, especially in regard to objectives is that this perspective undermines the fact that the educational outcomes can not be predicted with accuracy. Furthermore, the objective model does not consider the different ways in which subject matter can affect precision in stating educational objectives.

The technological abilities that surface in the literature are design, working in a practical-technical way, handling technological products, and technological awareness (Medway, 1993; Raat & De Vries, 1987). The STS approach which is implied by the Lesotho science curriculum objectives contributes towards technology education

through awareness (Layton, 1993). Since “awareness” is not easily measurable, this automatically excludes learning outcomes which relate to awareness. Hence the goal for an STS approach does not fit with learning outcomes which are precise, measurable and stated in behavioural terms.

The science-technology curriculum for Lesotho as shown in Section 6.2.2 strives for a scientifically and technologically literate society. In order to achieve this, learners need to acquire scientific and technological knowledge and skills which they can apply to solve everyday life problems. Layton (1993) argues that applying science in the everyday life context is not a simple matter. He indicated that in order to apply scientific knowledge in solving technological problems, science knowledge needs to be reworked since everyday life technological problems may require science knowledge from different science subjects at different levels of abstraction. Additionally, technological problems in everyday life are real and are different from modified science problems in the classroom, where for example, balls rolling down the inclined plane do not experience friction. It can be argued that the issues raised by Layton, can challenge the curriculum developers’ idea of developing learning outcomes for science incorporated with technology. The nature of the task of solving real life problems unless they are modified cannot be predicted with much accuracy. As such it would be difficult to indicate in precise terms what student should learn in solving a technological problem. Hence, this cannot be written as a precise learning outcome. These are some of the challenges which the science panel were faced with in trying to develop specific learning outcomes related to the STS approach. It is likely that what became easier was to bring in the technological applications towards the end of the curriculum process. The result of the latter was the mismatch between the objectives and the learning outcomes. Jenkins (2000:221) put it succinctly: “how are the ‘simple truths’ of school science and the ‘uncertainty of reality’ both to be accommodated” in the STS approach.

Based on the preceding discussions, the researcher assumes that in moving from the objectives of the syllabus to the learning outcomes and trying to state the learning outcomes in behavioural terms many important outcomes, which could have been associated with STS, were ignored. What remained were the outcomes mostly associated with science. The only alternative was to bring in some technological applications as examples where possible. The result was that most learning outcomes depicted the focus of the curriculum to be science content or encouraging technology-as-an illustration approach.

The mismatch between the objectives and the learning outcomes did not affect teachers in the study as they focused on learning outcomes. They were not aware of the objectives or their importance. Hence, they neglected the objectives of the science curriculum. Hence, the STS approach which was suggested by the syllabus objectives was ignored since the STS approach only appeared in the objectives.

The fact that teachers focused only on learning outcomes should be a concern because it indicated a lack of teacher training in regard to the curriculum under investigation. The objectives are supposed to indicate to teachers the intentions of the curriculum through the syllabus. If teachers do not have this understanding they will not know whether they are achieving the objectives of the curriculum.

Instead of being concerned with the mismatch between objectives and the learning outcomes teachers were more worried about the mismatch between the syllabus arrangement and the textbook. As indicated at the beginning of this chapter, the syllabus had arranged the topics according to the science content. However the textbook at times grouped different science topics under one chapter and named them differently. For example the topic waves was named “invisible science” in the book and appeared under the chapter “science around us” along with other topics. The researcher acknowledges that the textbook is not necessarily written for the syllabus. But in this case the textbook was the only exemplary material for teaching science incorporated with technology. As observed in this study when the textbook is arranged differently from the syllabus, this brings confusion.

In summary, the researcher is of the opinion that the Lesotho Junior science-technology curriculum had good intentions. The aim was to contribute to scientific and technological literacy through awareness. That is awareness of personal, social, moral, economic and environmental implications of technological developments. Hence the choice of an STS approach which is advocated by the syllabus objectives. However, the curriculum orientations held by the panel members and consequently the design model adopted made it difficult for them to achieve the intentions of the curriculum. The findings of the study indicate a mismatch between the syllabus objectives and the learning outcomes. These according to the researcher can be attributed to the fact that:

- The curriculum development process was hierarchical and sequential in nature, flowing from aims to learning outcomes. Hence indicating a technocratic perspective to curriculum development. Consequently, the model adapted was the one which

takes curriculum as a technical undertaking. In this model curriculum developers often focus on the process more than contents of what is being developed.

- The curriculum developers adopted the technical approach to curriculum development which is associated with behavioural objectives. The researcher assumes that the envisaged STS approach could not fit well with behavioural objectives. This is because STS approach contributes to technology education through awareness. Awareness is not easily measurable and hence learning outcomes related to STS approach were difficult to formulate. The result was the learning outcomes which depict science content or encouraged technology-as-an illustration approach.

However it was found that teachers did not see the mismatch between the syllabus statements because they focused only on learning outcomes and neglected the syllabus objectives.

Rather the teachers observed the mismatch between the syllabus and the textbook structure.

6.3 Question 2: How was the new science-technology curriculum implemented in the classroom

6.3.1 Introduction

There was an attempt to incorporate science and technology in the four case schools. The lessons were different from the traditional science lessons which focused on science content alone. However, lack of teacher training contributed negatively to the implementation of the Lesotho science-technology curriculum. As a result, science teachers in the study viewed technology education as generally perceived by science educators. Teachers perceived the science-technology curriculum as the curriculum that applies science in the everyday life context. According to Gardner (1999) this view regards technology as the application of science. Of the five approaches suggested in Gardner's (1990) model, the teachers were mainly using technology-as-an-illustration approach. The treatment of the technological applications however varied from mentioning the artefacts to discussing parts and functions and working of the artefacts. Even where teachers treated the artefacts in detail they still used them to illustrate a specific scientific principles or concepts. In dealing with some technological artefacts or issues science teachers were sometimes compelled to change the sequence of content. Thus they rearranged the content sequence across the three years of secondary education in order to explain some technological artefacts and issues. In doing so, teachers altered the scope and sequence of the JC science-technology syllabus. Furthermore,

in the absence of real artefacts teachers used diagrams to represent the technological artefacts and this made it difficult for learners to follow. This was more so in dealing with artefacts that learners had not experienced or seen before.

It is recognised that in a classroom situation there are many circumstances which contribute to shaping the discourse in a lesson. However, as far as technology integration was concerned, teachers' perceptions of the incorporation of science and technology, the syllabus scope and sequence and the physical facilities seemed to be related to the way teachers implemented the science-technology curriculum in this study.

6.3.2 The nature of teacher training relative to the implementation of the science-technology curriculum emphasis

As indicated in Section 5.4.4, the Lesotho education system has structures in place for providing both in-service and pre-service education to teachers. Yet the findings of the study suggest that there was no pre-service and in-service teacher training efforts geared towards the implementation of the science-technology syllabus. The pre-service providers relied on the Induction Programme which is the in-service programme run by the National University of Lesotho. It was found that the type of in-service work provided by this programme did not focus on subjects. Hence, it could not support science curriculum initiatives.

Nonetheless, there are other departments of the Ministry of Education which were supposed to provide in-service training for science teachers. These are the Central Inspectorate through the Science Inspector and the District Science Advisors. It was found that the Science Inspector rarely inspected science. Hence she could not specifically support science teachers through her office expert through the District Science Advisors. Although the District Science Advisors worked directly with teachers, they indicated during their interviews that they never focused on technology inclusion. Lack of support by the Ministry of Education in the implementation of the science-technology curriculum was voiced by all teachers in the study.

In short, science teachers in Lesotho did not get any pre-service or in-service training with regard to technology inclusion into science. It can therefore be assumed that their perceptions and consequently the way they treated technology inclusion in the science curriculum, was based on their interpretation of the syllabus and other curriculum materials that were at their disposal.

6.3.3 The teachers' perceptions of the science-technology syllabus

The word “syllabus” as used in the context of Lesotho refers to the official written document, which suggests to the teachers the aims, objectives, content, and the learning outcomes as well as assessment strategies for a particular subject. The Lesotho science syllabus therefore highlights the intentions of the planner, and to some extent the approaches which should be used in implementing the science curriculum. However the actual experiences of the learners, the interactions between the teachers, learners and materials, and the outcomes, which are the result of teachers' attempts to implement the planners' intentions can best be observed at school or classroom level.

As pointed out in the Section 6.3.2, science teachers in the study did not get training in relation to the implementation of the science-technology curriculum. It can be argued that their perceptions of the science curriculum that incorporates technology were not related to teacher training geared towards the implementation of the Lesotho science-technology curriculum. The teachers in the study perceived the science syllabus as the syllabus that applies science in everyday life. They took technology as the everyday life context upon which they could apply science. Fundamentally, they viewed technology as the application of science. Consequently they used technology-as-an-illustration approach in teaching.

These findings are in line with what was found in the literature relating to the perceptions that science educators generally have about the relationship between science and technology. According to Fensham (1988); Gardner (1994) and Gardner (1999) science educators generally understand technology to be the application of science. Furthermore Gardner (1994) reports on several studies in which it was found that secondary teachers assumed technology to be the application of science.

The findings of this study further show that the same understanding of the relationship between science and technology was found to be advocated by some of the Lesotho science syllabus statements, the textbook and the Junior Certificate Examinations. It can therefore be inferred that this perception of the relationship between science and technology runs across the different science educators in Lesotho.

The perceptions which teachers had about technology integrated with science manifested themselves in the way teachers conducted their lessons. In most cases teachers used technology-as an-illustration approach (Gardner, 1990). However, the depth of treatment of the technological applications varied from one school to another and from topic to topic. In

some instances teachers just mentioned the technological artefacts as examples. In other cases they described the artefact, showing its parts and functions as well as how the artefact works. Even where teachers elaborated on the artefacts their purpose was still to illustrate the scientific principles or concepts that were being taught.

The explanation for this could be that teachers were not guided enough by the syllabus with respect to what they should do with artefacts. This issue relates to the syllabus learning outcomes as discussed in Chapter Five. The researcher assumes that the learning outcomes associated with technology inclusion were interpreted differently by different teachers. Another possible reason for treating the applications at different levels could be the learners' background knowledge and experience with artefacts.

Learners' background made it difficult for teachers to go beyond the treatment of basic science content. The type of interactions that took place between learners and teachers differed from one case school to another. For example in one case school where learners were perceived to be high performers, the level of classroom interaction between the teacher and the learners was high. This was especially true of Lelimo high school. This made it possible for the teacher to treat some technological applications in the broader sense. In another case school the teachers had to postpone treatment of some applications because he believed his learners did not have experience or enough content knowledge to handle the applications. An example is Sofia High School where the teacher felt that his learners come from homes without electricity and therefore talking about electrical hazards would be meaningless if they have not covered current electricity at school. Current electricity was to be taught in the next grade.

Considering technology as the application places the treatment of technology at a higher cognitive level. It can be assumed that in order to apply science one should have the knowledge of science. It can further be assumed that where learners have poor science prerequisite knowledge it would be difficult to move to the higher cognitive level. As such this dictated how far the teacher could go in dealing with technological applications. This was confirmed by teachers in this study. The teacher at Jake high school indicated that it was not fruitful for him to bring many applications into the lesson when very few learners can follow basic science that he was teaching. Given the variation in the treatment of technological artefacts and issues, it could be presumed that learners were not experiencing the same curriculum as far as technology is concerned.

It is acknowledged that it is not practical to talk about the learners experiencing the common curriculum where the circumstances at school level are very different (Graham-Jolly, 2002). However this can be an issue in a system where learners have to sit for a common examination at one point. The examination assumes that the learners have similar experiences. In the case of this study, especially in relation to treatment of technological applications, some learners were only exposed to examples while others actually related the working of artefacts with scientific principles. Those who were exposed to artefacts as examples were disadvantaged. It is not surprising therefore, that learners did not perform well on the achievement tests especially with regard to applications, as indicated in the previous chapter. The average scores on application of science in everyday life, out of a total of 7 marks on electricity for Metheleng high school, Lelimo high school and Jake high school were 2.8, 3.8 and 2.1 respectively.

Despite the effort by curriculum developers to integrate science and technology, in practice the Lesotho science-technology curriculum has remained a science curriculum rich in technological examples. The envisaged STS approach did not materialise in the classroom. The findings of the study indicate that:

- As a result of lack of teacher training, teachers were not aware of the goals of the curriculum. Consequently they formulated their own perceptions of the integration of science and technology.
- Teachers in the study perceived technology as the application of science. In their teaching they used technology-as-an- illustration approach. Teachers apparently did not know about the STS approach.
- Learning outcomes which teachers relied on did not show the scope of treatment of different technological applications. As a result teachers treated the technological applications at different depth. Hence student experienced the curriculum differently in this regard.
- The learners' background knowledge and experience made it difficult for teachers to treat some technological applications since some student lacked the prerequisite knowledge.

6.3.4 The nature of the teacher-learner-material interaction

Sequence of learning outcomes

As indicated in Chapter Two the incorporation of technology and science goes beyond arguing for a certain innovation strategy, showing the different orientations and choosing the approaches for incorporating them. The point is reached where curriculum developers have to deal with issues relating to curriculum development and implementation. Gardner (1999) indicated that orientations can influence the curriculum developers' views but does not say how they should proceed with development, what content and how best it could be sequenced. The scope and sequence of learning outcomes seemed to be a problem to the teachers in the study. This suggests that the curriculum developers might have found it difficult to represent the approach they envisaged in the form of learning outcomes. The issue of transforming different innovations suggested by technology education curriculum into specific curriculum materials and practices has been raised by Layton (1994).

The teachers in the study perceived the science syllabus as the syllabus that applies science in everyday life (refer. to Section 6.3.2). They perceived technology as the everyday life context upon which they could apply science. In their efforts to incorporate technology, as they perceived it, teachers were faced with challenges that can be associated with the syllabus design.

According to Ornstein & Hunkins (2004) curriculum design exists along two basic organisation dimensions which are horizontal and vertical designs. Horizontal designs relate to integration of concepts from different subjects. Vertical designs deals with sequence and continuity. In trying to establish sequence and continuity concepts are introduced in one grade and reinforced or taught again in the following grade. As indicated in Section 5.2, the new science syllabus had arranged the learning outcomes for different content areas in accordance with what Ornstein & Hunkins (2004) and Parkay *et al* (2006) referred to as the vertical design. That is, the learning outcomes for a topic like electricity would be distributed over the three years of secondary education following the spiral approach. Important concepts would be reinforced in the following grade. However, the STS approach encourages integration and hence should follow a horizontal design as indicated by (Ornstein & Hunkins, 1993).

In dealing with some technological artefacts and issues, teachers sometimes found the learning outcomes for the grade inadequate in terms of the content required to explain the

technological issue at hand. In such cases teachers would either postpone the treatment of such applications or they moved the learning outcomes from higher grades into Form A. In that way they rearranged the sequencing of learning outcomes across the three levels of secondary education. For example, Maria could not deal with “wiring the three-pin plug, and earthing electrical appliances” without teaching all the electricity content from Form A to Form C (Grade 8 to Form Grade 10). She therefore rearranged the sequencing of learning outcomes. She brought all the content on electricity for three years of secondary education into Form A (grade 8) so that she could deal with wiring a three-pin plug and earthing electrical appliances. This may appear extreme, but she was not the only one making this decision. Some teachers also did that in teaching other topics. In her case she could not deal with the three-pin plug without dealing with colour coding. Colour coding demanded that she refer to neutral, live wire and earthing. The notes she gave to the student after teaching electricity indicated how detailed wiring a three-pin plug could be to her. Her notes appear in Section 5.5.3. Rearranging the syllabus sequence as described interfered with the time allocation for the different content areas. There is a reason content is sequenced in a particular way in the syllabus. Moving the content to the next grade, means that teachers and learners will have to cover more work in the following year. In case the teacher brings the content from the other level into Form A, the amount of content the student would need to cover in Form A increases. This works against the purpose of sequencing content in the syllabus. As such Maria had to rush through the topic electricity. This illustrates the issue of conflicting designs; the curriculum objectives suggest integration which is a horizontal design but the learning outcomes adapt the spiral approach which is associated with the vertical design.

In brief, the science-technology curriculum through its objectives advocated an STS approach. An STS approach by its nature encourages an integrated curriculum. However the science panel used the curriculum design which emphasised sequencing and continuity. In trying to implement the science-technology curriculum teachers struggled with sequence of learning outcomes. Teachers in most cases had to rearrange content in order to treat some technological applications. They either postponed content to upper grades or they moved content from higher grades to the grade they were teaching. By so doing, they distorted the content sequence and consequently adapting the vertical design.

Scope of content

The second challenge was in relation to the scope of learning outcomes, especially those related to the incorporation of technology. The learning outcomes dealing with technological applications did not adequately specify the scope of dealing with technological applications. As a result teachers treated technological applications at different levels. As indicated in Chapter Five, in some cases teachers mentioned the technological applications as examples, in some instances they explained them in relation to the science content they were teaching. In more advanced level they would describe the parts and functions of the technological artefacts they were regarding as the application of science. The learners from the different case schools were therefore experiencing different curricula as far as technological applications are concerned. The issue here is whether it is important to study the different artefacts or acquire certain technological competencies through the study of these artefacts. As indicated in the previous section the science panel seems to have had difficulty in stating learning outcomes related to technology inclusion. This phenomenon as observed in this study made it difficult for teachers to sense the depth at which they had to treat the different technological artefacts.

In summary, the learning outcomes associated with the technological issues did not indicate the scope of treatment of these issues. As a result the depth at which the applications were treated by teachers varied from one school to another and from one topic to the other. Consequently learners did not experience a common curriculum as far as technology is concerned.

Physical facilities

The third challenge was associated with physical facilities, especially those that could be used to show and demonstrate the working of technological artefacts. The researcher recognised that pictures and diagrams are often used in science lessons. In many cases diagrams have proven to be valuable. Some technological applications that teachers worked with were artefacts. In the absence of real artefacts, and models of artefacts, teachers used diagrams, but it appeared diagrams could not represent technological applications well. For example the teacher dealing with the car braking system or the hydraulic lifter, representing these artefacts diagrammatically did not illustrate this well. It was evident that some explanations relating to technological artefacts required models, or simulated artefacts and sometimes real artefacts. Layton (1993) in dealing with the issue of “reworking science” in order to apply it in everyday life, indicated that the teaching of science has more often depended on simplifying

real life situations, and when dealing with technological applications, there is need to bring the real contexts of the technological applications back into teaching. As observed in this study, diagrams which are used for artefacts sometimes move the technological artefacts away from real life.

In brief, dealing with everyday life issues require that the everyday context of artefacts and issues be brought into the classroom (Layton, 1993). Due to lack of physical facilities especially technological artefacts, teachers had to rely on diagrams. Diagrams in some cases lacked the everyday life context.

6.3.5 The outcomes of the science-technology curriculum

The aim of the Lesotho science-technology curriculum as depicted by the curriculum was to attain scientific and technologic literacy. The Science Panel planned to achieve this goal by integrating science and technology. According to the results of the study the intended approach for integrating science and technology was the STS approach. However the study suggests that this goal was difficult to achieve since the envisaged STS approach was not implemented in the classroom. Hence the goal for the Lesotho science-technology curriculum has remained a statement of intent and a claim about technological and scientific literacy. The study suggests several contributing factors to this state of affair.

The results of the study suggest that the science panel viewed curriculum development as a technical process. In that case the panel might have focused more on the procedure of curriculum development than rationalising the different stages in the process. The outcome of which was the mismatch between the syllabus statements.

The results of this study further show that there were no pre-service and in-service teacher training initiatives arranged to support the implementation of the science technology curriculum. As a result teachers formed their own meaning of technology integrated with science. They perceived science as the application of science. Although all teachers in the study perceived the science curriculum as the curriculum that attempts to apply science in everyday life, the level of abstraction at which they treated the technological artefacts varied. For that reason the curriculum which the learners experienced as far as the technological applications are concerned was not the same.

The curriculum design adopted by the panel seemed to be in conflict with the envisaged STS approach. The content sequence in the syllabus followed the spiral approach. In trying to

deal with some technological applications and issues teachers had to rearrange the content sequence. As indicated in Chapter Two, curriculum as technology is associated with learning outcomes which are stated in behavioural terms. The results of the study suggest that the panel found it difficult to state learning outcomes associated with technology in behavioural terms. Consequently teachers interpreted the learning outcomes associated with technology differently.

As indicated in the literature, technology requires that the everyday context of artefacts be brought in to the classroom. As observed in this study, dealing with some artefacts required teachers to use more advanced equipment than that found in the normal science laboratory. In the absence of real artefacts, teachers used diagrams. Diagrams seemed to remove the everyday context of artefacts.

As indicated Section 6.2.2, the science-technology syllabus had separated the science subjects. This made it easier for teachers to separate the sciences on the timetable and when teaching. This was found to be one of the circumstances which made it difficult for teachers to use content from different science subjects in dealing with technological issues. In some cases it caused teachers to postpone the treatment of some technological applications. This further contributed to the difference in the experiences provided to learners.

In short, the curriculum statements which were supposed to dictate the planned curriculum to teachers were not consistent. Teacher training efforts which were supposed to have guided teachers in interpreting the developers' plans were missing. Consequently, teachers interpreted the intentions of the curriculum developers differently.

The outcome was a science curriculum which focused more on science content and principles and rich in technological examples. Yet learners did not experience similar curriculum in relation to technological applications. As a result of the issues discussed above, learners did not perform well on the achievement tests that were given to them at the end of every chapter. The performance was even poorer in the case of items which dealt with the application of science. The test results for electricity show this performance (refer to 5.6.6). Similar performance was also found in other tests.

The Lesotho science-technology curriculum has been a good attempt to promote technological and scientific literacy. However, the curriculum developers' of curriculum development, the process of curriculum development and lack of teacher training have led to a curriculum which in practice is essentially a science curriculum rich in technological

examples. Hence it can be concluded that the planned STS approach did not materialise in the classroom.

6.4 Implications

6.4.1 *Implications for the curriculum*

The aim of the Lesotho science curriculum which incorporates technology, as indicated by the results of the study, was to enable learners to acquire scientific and technological knowledge, skills and attitudes that would enhance scientific and technological literacy for learners to be able to participate effectively in social issues and activities. The objectives of the syllabus indicate that the approach that was intended to be used in this regard was an STS approach. However this aspiration has been difficult to achieve. The findings of the study suggest that:

- The curriculum orientations held by the curriculum developers and hence the curriculum development approach and curriculum design that were adapted in developing the science-technology curriculum could have been a hindrance.
- Lack of teacher training which resulted in teachers formulating their own conception of the integration of science and technology could have contributed to lack of success.

As indicated in Section 6.3.4, the Lesotho science curriculum developers held a technocratic perspective to curriculum. Hence, the model that was used in developing the curriculum assumed curriculum development to be a technical process. Eisner (2004), suggested that the nature of the technical perspective is that curriculum developers put more effort into the process of curriculum development than to critically rationalise the different components of the process.

The results of the study suggest that the curriculum developers in the study focused on the steps for developing the curriculum rather than being critically engaged in the process. The mismatch between the syllabus objectives and the learning outcomes is evidence of this. The researcher further believes that the conflict between the design that was adopted in designing the science-technology syllabus and the approach that was intended to be used in integrating science and technology can also be attributed to lack of critical engagement.

Based on the results of the study it is evident that curriculum development can not be assumed to be a technical procedure. The process of curriculum development involves

critical engagement in all the steps that are taken in curriculum making. This process further requires curriculum developers to adopt curriculum models to context. Following a curriculum model dogmatically, as can be seen in this example where the spiral approach was used in the case of development of the science-technology curriculum, can sometimes neglect context.

As stated before, curriculum development involves more than knowing the procedure. It involves having a broad and elaborate understanding of the curriculum area and knowledge about trends, debates and pertinent issues relating to the area in which the curriculum is to be developed. As such broad and detailed research into the area of curriculum innovation is required before any changes in curriculum are carried out.

6.4.2 Implications for research

De Vries (2006) indicates that there is very little research in relation to curriculum content in technology education. This study has presented the nature of the Lesotho science-technology curriculum. It has also shown how this curriculum was implemented in the case schools. Although the study has shown the nature of the planned and the implemented Lesotho science-technology curriculum, it has not been able to indicate the essential competencies in a science and technology curriculum. This remains an area which needs to be researched empirically. The research in this area would set standards against which curriculum initiatives such as in the case in Lesotho could be judged. Furthermore, such research could serve as a guide in developing the science-technology curriculum.

In the case of Lesotho, the curriculum developers' plan which is the syllabus indicated the objectives of the science-technology curriculum as well as how teachers should achieve these objectives. However teachers were unable to present similar experiences to learners in relation to technological applications. As such it cannot be claimed that learners experience a common curriculum. National assessments which assume a common curriculum are not justifiable for the learners in this case. The study therefore suggests that there is a need for research into which type of competencies should national assessments examine in testing learners' abilities to deal with technological applications.

6.5 Concluding remarks

This study has evaluated the Lesotho Junior secondary science-technology curriculum by investigating the nature of the intended and the implemented curriculum. The results of the study indicate that the science-technology curriculum strive towards the attainment of a scientifically and technologically literate society. However, the findings of the study indicate that it has been difficult to achieve this goal. The technocratic perspective to curriculum development and consequently the curriculum design model adapted by the curriculum developers might have contributed to lack of success in the attainment of the goals of the curriculum. Furthermore, lack of teacher training which resulted in teachers in the study formulating their own perception of science integrated with technology, could have made it difficult for the science-technology curriculum to be implemented as envisaged by the curriculum developers. In addition, learners' background knowledge was also found to be a hindrance as teachers tried to implement the curriculum the way they perceived it.

The technocratic perspective to curriculum development assumes curriculum development to be a technical undertaking. This assumption makes curriculum developers focus more on the process than on the different steps involved in the process. As a result, the findings of the study indicate a mismatch between the syllabus objectives and the learning outcomes. Furthermore, the technocratic approach to curriculum development is associated with behavioural objectives. The results of this study show that the STS approach which contributes to technology education through awareness did not fit well with learning outcomes which are precise and stated in behavioural terms. This according to the research is probably because "awareness" by its nature is attitudinal; hence it is not easily measurable.

Related to the STS approach which was the envisaged approach in the curriculum are the issues of separating the sciences and the scope and sequence. The science syllabus had separated the sciences into biology, physics and chemistry. An STS approach encourages integration, and separating the science subjects therefore contradicts this approach. The findings of the study indicate that three out of the four schools in the study also separated the science subjects on the timetable and in teaching them. Hence, implementing the STS approach became difficult. The scope and sequence of the science syllabus was found to be following the spiral approach and based mostly on science content. In dealing with technological applications teachers had to rearrange the sequence.

Due to lack of teacher training teachers formulated their own perception of technology integrated with science. The results of the study indicate that they perceived technology as the application of science. In their teaching they often used technology-as-an-illustration approach. As a result the STS approach was not implemented as planned by curriculum developers. In addition it was found that teachers relied heavily on learning outcomes. But the learning outcomes did not indicate the scope of treatment of different technological applications and artefacts well. Hence, teachers treated the technological applications at different conceptual level. Consequently, learners did not experience similar curriculum as far as technological applications are concerned.

The Learners in the study had different experiences and different science background which made it difficult for teachers to treat some technological applications. As a result, the teachers were forced to transfer content from the grade they were teaching to the upper grades or to move content from upper grades to lower grades. This worked against the principles of sequencing content.

In brief, the aim of the science-technology curriculum, which is to attain scientific and technological literacy, has remained a statement of intent. What has been implemented is a science curriculum which is rich in technological examples. The factors which have contributed to this state of affairs are the technocratic perspectives to curriculum held by curriculum developers, the teachers' perception of technology integrated with science and the learners' prerequisite knowledge.

6.6 Questions unanswered

The data that were collected in this study focused on physics. As a result, more data would be required to establish how the teachers dealt with biology and chemistry. Furthermore, the data on the observations and document analysis was based only on three topics in physics. Studying all physics topics could have allowed the results of the study to be generalisable in terms of physics. However, this was not the case and as such the results of this study are confined to the topics which were studied which are: electricity, pressure and waves. Furthermore, research is needed to establish if the patterns of findings found regarding some physics topics would also apply to topics in other areas, such as biology and chemistry.

The achievement tests that were administered to learners in this study were meant to investigate whether learners had acquired the intended content and skills as prescribed by the

syllabus. As a result no pre-test was administered to learners. In order to find out if the approaches used by teachers enhanced learning of some science topics a pre-test would have to be administered. This is an area this study did not venture into. Finding out whether the approaches used by teachers in the study would improve the acquisition of science content and skills would be an interesting area of research. Such research would contribute towards the development of science teaching and learning.

The intended curriculum was developed by experts in the science panel. However, the findings of the study show that teachers modified the syllabus sequence and had problems with the content scope. It would be interesting to find out how practising teachers would sequence the content of the science-technology syllabus. This type of research would work towards closing the gap between the intended curriculum and the implemented curriculum.

6.7 Recommendations

Based on the results of the study, some recommendations can be made which can support future efforts to improve the science-technology curriculum in Lesotho and elsewhere where such initiatives will be undertaken. It is acknowledged that some of the recommendations although based on the results of the study, might be similar to others that have been suggested elsewhere in the literature.

Firstly, the study suggests that the curriculum design and development models are not tailor-made to suit every context. Hence it is necessary to contextualise the curriculum models. This suggests that the National Curriculum Development Centre (NCDC) in Lesotho cannot depend on one curriculum model for all the different subject areas. There is a need to evaluate the curriculum design and development models which are used against the theoretical underpinnings of an STS approach. The NCDC in Lesotho would therefore need to deliberate and determine which approach to science-technology syllabus they find best suitable for Lesotho context.

Secondly, curriculum innovations usually follow global trends. Consequently there is a substantial body of research on the innovations related to technology education. It is therefore recommended that the curriculum developers in Lesotho should familiarise themselves with this literature so that they become acquainted with trends, debates and pertinent issues in technology education.

Thirdly, the study has indicated that without teacher training, teachers find it difficult to interpret the intentions of the curriculum planners. As such teacher training is required in Lesotho to support the curriculum initiative which the study has investigated and others that may follow.

Lastly, the attempt to incorporate science and technology in the Lesotho Junior science curriculum is a worthwhile experience for all stakeholders in science education in Lesotho. The knowledge and skills that curriculum developers, teachers, examination subject officers and learners have gained through this curriculum initiative is valuable. It has contributed significantly towards the improvement of science education in Lesotho. Nonetheless, curriculum studies are about the relationship between intentions and practice. Focusing on one aspect of curriculum widens the gap between the intended curriculum and the experienced curriculum. As a result, isolating curriculum development from the context in which it is intended to operate brings about the mismatch between the plan and practice. As part of needs assessment for developing curriculum, the developers ought to do surveys of teachers' and learners' capabilities as well as schools support abilities.



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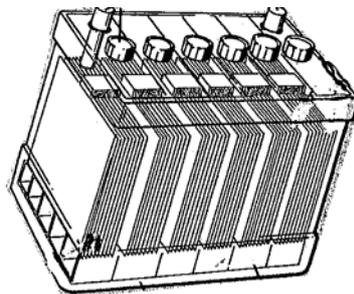
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Appendices

Appendix 1 Achievement tests

TEST A-Electricity

1. (a) The simple battery as the one shown in the diagram is the source of electrical energy for many people in Lesotho.



- (i) What type of battery is it?

.....(1)

- (ii) Other than the battery, what are the other two sources electricity which is used in Lesotho?

..... (2)

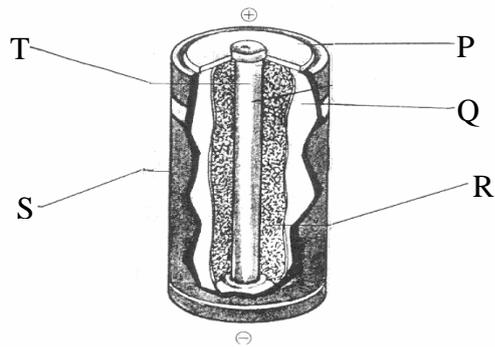
2. A boy connected the cells in a torch as shown below.



Would the torch light? Explain your answer.

.....(2)

3. The diagram below shows a dry cell.



Which two of the labelled parts are the electrodes? (2)

4. Mrs Mofolo buys a new kettle and asks you to connect the lead to a three pin-plug. The lead has three wires inside it, each wire is covered with a different plastic insulation. The insulations are green with yellow strips, blue and brown.

- (i) Why are the wires insulated?(1)
- (ii) What colour is the earth wire?.....(1)
- (iii) What colour is the live wire?.....(1)
- (iv) Which colour is the neutral wire?.....(1)
- (v) Which wire is a safety wire?.....(1)
- (vi) Which wire is most dangerous ?.....(1)



(vii) Why is it called the live wire.....(1)

(viii) Why are so many electrical appliances made from plastic?... (2)

5. You are given five red bulbs, and three green bulbs, two switches, and two cells and connecting wires. You plan to decorate a tree for Christmas.

Draw a circuit diagram that will allow the following to happen to your light;

(i) The green bulbs should light independent of the red bulbs.

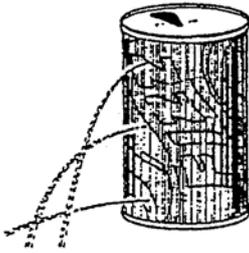
(ii) The green bulbs should light all at the same time.

(iii) The red bulb should light all at the same time. (3)



TEST B-Pressure

1. What do you understand by pressure?.....(1)
2. Pressure is measured in which of the following units?
 - A. Newtons
 - B. Joules
 - C. Pascals
 - D. Cubic millimetres.(1)
3. Three holes are made in a fizz drink can filled with water as shown in the diagram below.

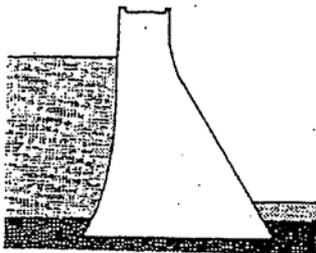


Why does the water run or squirt further out of the bottom hole?.....(1)

Fill in the missing word in the sentences below

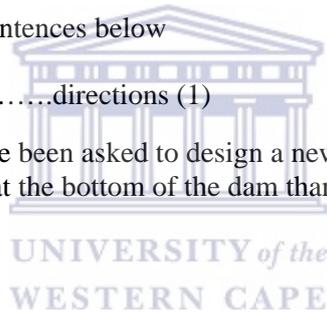
In liquids, pressure acts indirections (1)

4. You are an architect and have been asked to design a new dam for your town. Your sketches show a wider wall at the bottom of the dam than at the top as shown in the diagram.

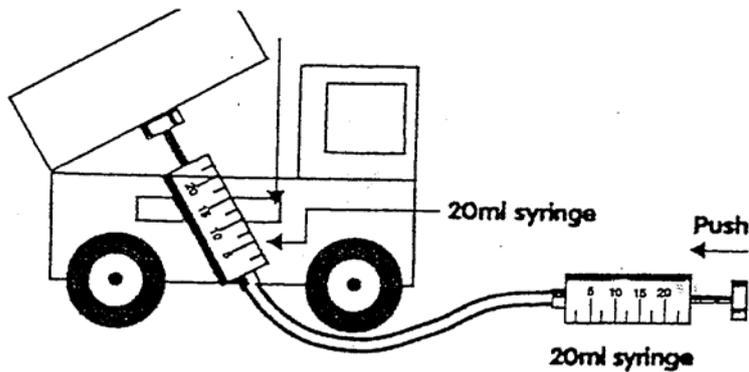


Explain why you designed the dam wall in this way.

.....(2)



5. The picture below shows a hydraulic syringe system that can be used to lift the back of the toy tipper truck.



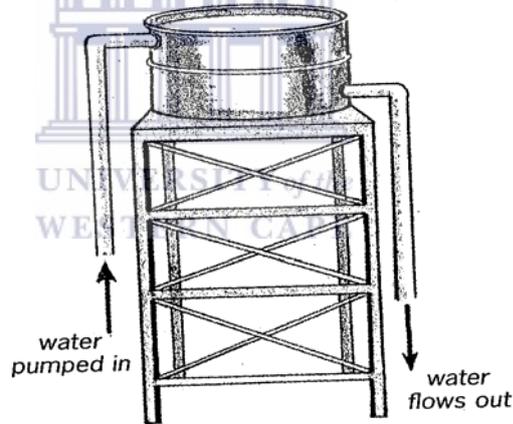
- (a) What would work better: A syringe system filled with water or a syringe system filled with air? Explain your answer.

..... (2)

- (b) List two things in which a hydraulic system is used in everyday life.

.....(2)

6. In rural areas water is sometimes obtained from boreholes. The water is bored from the ground and pumped into the water tanks for storage. The tanks are put on high stands. The water is pumped using electricity. The diagram shows the storage tank for water.



A water tank

(Water supply to the household)

- (a) Why is it necessary to put the tank on a stand? (1)

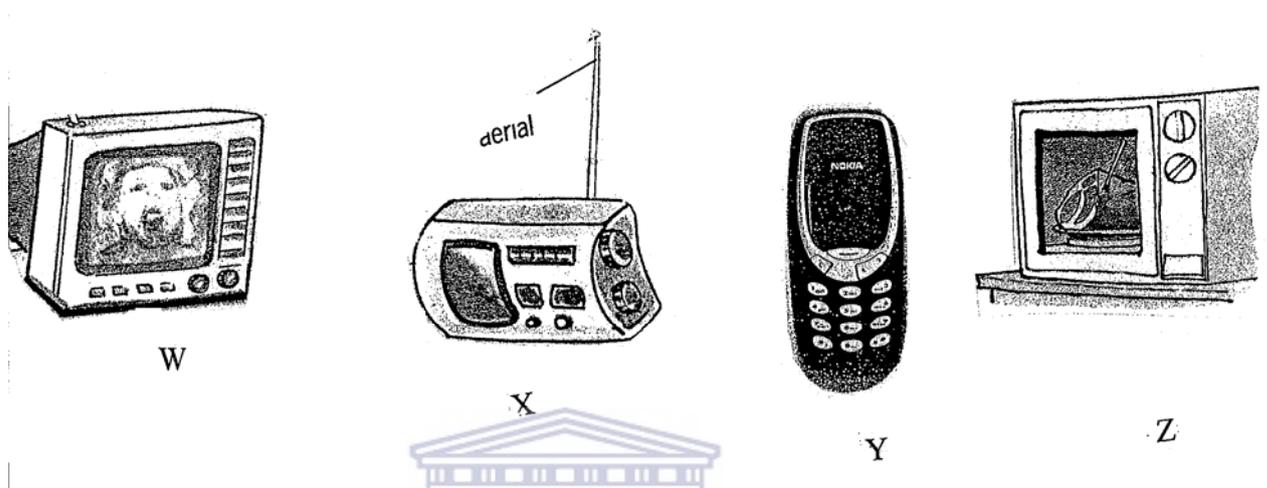
- (b) Suggest the reason for placing the pipe that supplies the house at the bottom of the tank.....(2)

- (d) Mr. Thabo has a borehole and the water from his water tank does not come out with enough pressure to allow him to water his plants. What should Mr Thabo do to increase the water pressure?

.....(3)

TEST C-Waves

1. Name two types of electromagnetic waves.
.....(2)
2. Which two types of electromagnetic waves are used in Hospital?
.....(2)
3. Give one difference between sound waves and all electromagnetic waves.
..... (1)
4. The diagram below shows some appliances used at home.



Which of the following statements are true or false about the appliances above? Indicate by writing the word true or false in front of each statement.

- (a) Appliance W is a producer of TV waves.(1)
- (b) Appliance Y detects electromagnetic waves. (1)
- (c) Appliance Z uses micro – waves to cook food.(1)
- (d) A radio usually has an aerial. What is the function of the aerial in this appliance?
.....(1)
- (e) A radio is commonly used in many houses in Lesotho.
Describe how you receive news broadcaster form the radio station through the radio?
.....(3)
- (f) There are some communities in Lesotho, which can not receive Radio Lesotho all.
Which of the following communities in Lesotho are not likely to receive Radio Lesotho? Are they Villages in the valleys or villages on top of the mountains? Explain .
.....(2)
- (g) Some people who can not get radio Lesotho clearly and they move to the top of a hill to get radio Lesotho clearly.
Explain how this is possible.
..... (2)

5. Which of the following statements correctly describes what ultrasound is. **(Circle the correct answer)**

- A. Ultrasound is the name of the sound waves, which travel at a frequency below the level that can be heard by human beings.
- B. Ultrasound is the name of the sound waves, which travel at a frequency higher than the level that can be heard by human beings.
- C. Ultrasound is the name of the electromagnetic waves, which travel at a frequency below the level that can be seen by human beings.
- D. Ultrasound is the name of the electromagnetic waves, which travel at a frequency below the level that can be seen by human beings. (1)

6. When Doctors need to see an image of unborn baby which one is the best between **ultra sound** and **an X-ray**. Explain your answer?

.....(2)..

TOTAL (20)



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Appendix 2 syllabus-analysis-schedules

Syllabus analysis schedule

Syllabus part		Science and technology approach encouraged					
		Technology-as-an-illustration	Cognitive-motivational-approach	Technology-as-an-artefact	Technology-as-a-process	Science and technology and society	Laboratory /classroom approach
Introduction							
Mission statement							
Suggested approaches							
Assessment							
Suggested equipment							
General objectives	1.0						
	2.0						
	3.0						
	4.0						
	7.0						
	16.0						
	17.0						
Specific objectives	1.1						
	1.2						
	1.3						
	1.4						
	1.5						
	1.6						
	2.1						
	2.2						

	3.1						
	3.2						
	4.1						
	4.2						
	5.1						
	5.2						
	7.1						
	16.1						
	16.2						
	16.3						
	17.1						
Learning outcomes	Electricity						
	Waves						
	Pressure						

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1. **Technology-as-an-illustration**-it when technological applications are presented after instructional sequence based on the scientific concept and principles. For example, magnetism, magnetic induction, temporary and permanent magnets, as well as electromagnetism are taught to learners using the usual laboratory/classroom approach and at the end the electric bell (technological artefacts) is disassembled to demonstrate the working of the electromagnet using the electric bell.
2. **Cognitive-motivational-approach**-technological applications are introduced early in the instructional sequence in order to stimulate interest and enhance meaningful learning. For example, the teacher disassembles the old TV set (technological artefact) to show the learners the electron tube. The learners are motivated towards learning about the working of the television. S/he puts the artefact aside and goes back to teach about deflection of electrons in the tube, to demonstrate the deflection of electrons by the magnetic field making very little reverence to the electron tube or not at all.
3. **Technology an artefact**-real or simulated artefacts are disassembled (taken apart literally or intellectually) in order to develop understanding of the various parts of the artefact, how they interact and the scientific principles involved. The scientific knowledge is brought in to explain. For example, disassembling the cooling system of a car (technological artefact) looking at the component parts, showing how they work and relating them to scientific principles such as methods of heat transfer when necessary. The focus should be the artefact. Science concepts are brought where necessary.
4. **Technology-as-a-process**-technology is regarded as a process of problem solving (inventing, designing, and making). Scientific ideas are relevant if they contribute to this process. Historical development, case studies and problem solving are central to the process. For example, looking at the Historical developments of the steam engine i.e. what brought about

the need, the process of inventing it, problems encountered, and may be letting learners investigate further about it. Then asking them to design or improve on a given model of the steam engine.

5. **Science, technology and society approach**-This approach puts less emphasis on scientific content and technological capabilities but deals more with the problematic nature of scientific knowledge and upon interdisciplinary nature of knowledge in an attempt to show how science and technology are shaped by social forces, and how they affect society. Awareness of the personal, social, moral, and environmental implications of the technological development is central to this process. For example, building a borehole pump for the village. There is a technological artefact at the centre of the project but there are other issues such as maintenance, health hazards, economic factors, durability, sustainability, management of the borehole etc . which learners are challenged to look into (Gardner, 1990)

6. **Science content only**-This approach does not make reference to any technological artefact. It is purely based on science laboratory work and other classroom approaches. For example teaching magnetic field, demonstrating it with the iron fillings and bar magnets with no reference to any technology.



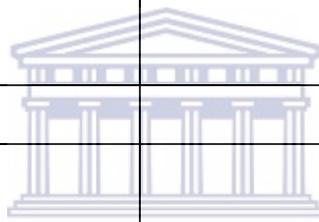
Appendix 3 textbook-analysis-schedules

analysis schedule

chapter: Electricity and magnetism (focus on electricity)	Science and technology approaches encouraged					
	Technology-as-an-illustration	Cognitive-motivational-approach	Technology-as-an-artefact	Technology-as-a-process	Science technology and society	Laboratory and Classroom approach
Introduction diagram						
Introduction questions						
Electric cell						
Connecting bulbs						
Safety first						
Earthling						
Chapter review						
Extend yourself						
chapter: Science around us (focus on Pressure)						
	Technology-as-an-illustration	Cognitive-motivational-approach	Technology-as-an-artefact	Technology-as-a-process	Science technology and society	Laboratory and Classroom approach
Introduction diagram						
Introduction questions						
Water and pressure						
Pressure with depth						

Applications of fluid pressure						
Pressure of the atmosphere						
Chapter review						
Extend yourself						
chapter: science around us (focus on waves)						
	Technology-as-an-illustration	Cognitive-motivational-approach	Technology-as-an-artefact	Technology-as-a-process	Science technology and society	Laboratory and Classroom approach
Introduction diagram						
Introduction questions						
Invisible science						
Visible light						
Infrared radiation						
Ultraviolet radiation						
Microwaves						
X-rays and gamma rays						
Radio waves						
Chapter review						
Extend yourself						
Topic	1 st and 2 nd page					

	3 rd and 4 th page						
	5 th and 6 th page						
	7 th and 8 th page						
	9 th and 10 th page						
	11 th and 12 th page						
Chapter review							
Extended review							



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Appendix 4 interview instruments

A. Head of Department interview questions

1. Briefly describe your duties as the head of science department?
2. What are your feelings about the JC science syllabus?
3. What do you think learners are supposed to learn in this syllabus?
4. What type of a teacher do you think would be most appropriate for teaching this syllabus?
5. Do you think your teachers are teaching this syllabus as expected? Elaborate.
6. What sort of support structure is there to support teachers in case they need help with their teaching?

B. Science teacher interview questions

SchoolTeacher' name.....

1. How do you feel about the science syllabus that you are teaching?
2. What type of challenges do you come across in teaching the syllabus?
3. What do you think the children are supposed to learn in this syllabus?
4. What do you think the syllabus requires from you as the teacher?
5. Do you think you are teaching the syllabus as expected? Elaborate.
6. Are you aware that you are teaching a science syllabus that integrates science and technology?
7. Can you explain what you understand by integrating science and technology?
8. Do you think your teacher training has prepared you adequately to teach the above topics? Elaborate.
9. Are you getting any educational support to help you teaching the syllabus?
10. Do you think your learners have adequate background to handle the topics above in Form A. Explain.
11. Do you think your school has resources to allow you to adequately teach the above topics? Explain.
12. How do you use the textbook in your teaching of the above topics?
13. Do you think the textbook is adequate? Elaborate.
14. How do you assess your learners?
15. Briefly describe your opinion about how science should be taught at JC level.
16. Any comments on the teaching of science at JC level.
- 17.

C. Experts interview questions.

The expert interviewed

Place of work

Education Background.....

1. What did the panel aim to achieve by integrating science and technology
2. How was the science knowledge intended to be integrated with technology?
3. What pupils characteristic are necessary to make them able to deal with the new science curriculum?

The general prerequisites

Specific prerequisites

4. What teacher characteristics are necessary to allow them to deliver the science curriculum?

Teacher qualifications

Any specific prerequisite

5. What sort of classroom arrangement would be suitable for the delivery of the curriculum?
6. What type of materials should the schools have in order to allow proper implementation of the curriculum?
7. How are the science teachers expected to teach the syllabus?
8. What is the supposed role of the teacher in class?
9. How is the textbook expected to be used?
10. What should be the role of pupils in class?
11. How are the teachers expected to assess pupils?
12. How are the teachers expected to go about integrating science and technology?



Appendix 5-The science-syllabus (parts relevant to the study)

A. General information

Introduction

The Lesotho Science curriculum consists of the three disciplines: Biology, Chemistry and Physics. The Technology and Environment aspects as well as the Population and Family Life issues have been incorporated into the three disciplines where appropriate. It is intended that in the syllabus, the linking concepts should be treated accordingly, so that the learners should realize them and not treat them in isolation. The teacher is advised to use what is familiar to the learners to teach new concepts. The syllabus is designed for learners who will be leaving school after Form C as well as those who will be proceeding to senior secondary education, either specialising in science or not. It is also intended for those learners who will be studying science at tertiary level

Mission Statement

The purpose of the Science curriculum is to enable the learners acquire knowledge, skills and attitudes in science and technology that would enhance permanent and functional literacy and numeracy for continuous learning and effective participation in social issues and activities. These include development of basic skills of research, ability to form new ideas, solve problems, design and produce materials for self-directed learning in all situations. These would enable the learners to adapt, utilize, invent and influence the scientific, technological and socio-economic changes locally and globally. The learners will acquire attitudes in science such as curiosity, inquisitiveness, critical thinking, and creativeness which, together with the scientific skills will be used in survival in the rapidly changing world, and applied for improvement of life in the society as well as the quality of the environment. It is hoped that the learners will relate the science they learn through this curriculum to everyday phenomena in their immediate environment and beyond.

Approaches

It is intended that in teaching this syllabus, learner-centred approaches and methods should be used, these include, among others:

- Practical work through experiments
- Inquiry through investigations
- Projects involving analysis, synthesis and designing of articles/items.

It is important to also realize that learners come to school with certain knowledge of science, which should not be ignored but improved upon. The relevance of what they are learning to everyday life situations should also be brought to their attention

Assessment

In addition to assessment techniques employed daily throughout the course, the main ones to be used at the end of each level (year) and at the end of the course will be paper-and-pencil examinations. Techniques to be employed should cater for knowledge and skills at different levels of cognition.

Projects involving investigations, surveys, design and production of articles/items Form part of the syllabus and have to be assessed continuously.

End of year examinations

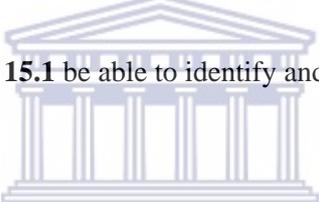
LEVEL	NO. OF PAPERS	SECTIONS	MARKS/SECTIONS	QUESTIONS
FORM A	ONE	THREE	A = 30 B = 30 C = 30	<ul style="list-style-type: none"> • multiple choice • short structure questions • short essay type questions • 10 marks for each discipline in every section
FORM B	TWO	PAPER 1-NONE PAPER 2-TWO	45 A = 60 B = 30	<ul style="list-style-type: none"> • multiple choice • semi-structured questions • essay type progressive questions • all questions in every section are compulsory
FORM C	As in Form B	As in Form B	As in Form B	Do

B. General and specific objectives for the new science curriculum

(The objectives related to inclusion of technology are bolded)

<p>6.8 GENERAL OBJECTIVES=SUBJECT AIMS</p>	<p>SPECIFIC OBJECTIVES = END-OF-COURSE OBJECTIVES</p>
<p>1.0 have developed awareness and appreciation of scientific and technological activities, and interdependence of scientific, socio-economic and technological changes in Lesotho and other countries</p>	<p>1.1 identify scientific and technological activities going on in the environment (home, school, community, globally) Lesotho and other countries. 1.2 identify the effects of scientific and technological changes on the socio-economy of Lesotho and other countries 1.3 describe the effects of scientific and technological changes on the socio-economy of Lesotho and other countries 1.4 describe the importance of scientific and technological activities in Lesotho and other countries 1.5 relate scientific and technological activities to socio-economic and technological changes 1.6 describe the interdependence of scientific, socio-economic and technological changes</p>
<p>2.0 have developed understanding of how socio-economic and technological changes can affect survival of various species</p>	<p>2.1 be able to evaluate how socio-economic and technological changes can affect survival of various species 2.2. be able to describe the effects of socio-economic and technological changes on survival of various species</p>
<p>3.0 have acquired scientific knowledge, skills and attitudes to solve problems related to socio-economic and technological changes</p>	<p>3.1 be able to identify problems related to socio-economic and technological changes 3.2 be able to solve problems related to socio-economic and technological changes</p>
<p>4.0 be able to apply scientific knowledge and skills in developing new ideas and solving problems due to socio-economic and technological development (in Lesotho)</p>	<p>4.1 be able to design methods to solve problems due to socio-economic and technological developments 4.2 be able to produce materials for solving problems within the framework of social norms and economic potential of Lesotho</p>
<p>5.0 have acquired skills in communicating oral and written scientific and technological</p>	<p>5.1 be able to use effectively symbols developed by Bureau of standards for communicating scientific and technological information</p>

information	
	5.2 be able to produce correctly pictorial representation of scientific and technological information from a given instruction
6.0 have developed confidence, responsibility and ability to apply scientific method in developing new ideas, solving problems, designing and producing material for self-directed learning and for learning in all situations	6.1 be able to apply scientific method to reason constructively for an innovative design to specifications
7.0 have developed the ability to apply appropriate scientific and technological skills for survival in everyday life and new situations	7.1 be able to apply appropriate scientific and technological skills to produce saleable items which are safe, eye-catching and easy to use
8.0 have developed scientific skills, knowledge and attitudes which enable them to care for and improve the environment	8.1 be able to participate appropriately in environmental activities 8.2 be able to solve local environmental problems
9.0 have acquired scientific knowledge, skills and attitudes that would enable them to respond appropriately to environmental changes and disasters	9.1 be able to identify environmental changes 9.2 be able to distinguish between positive and negative environmental changes 9.3 be able to identify causes of environmental changes 9.4 be able to solve problems related to negative environmental changes
10.0 have acquired scientific knowledge, and skills for population management and its implications for the environment	10.1 be able to identify factors affecting human population growth and its management 10.2 be able to explain how these factors affect population growth and its management 10.3 be able to apply acquired scientific knowledge and skills to solve the problem of population explosion
11.0 have developed scientific and skills to interact with the environment appropriately	<i>As in 10.0</i>

<p>12.0</p> <p>have developed scientific skills and attitudes that would enable them to be self-reliant</p>	<p>12.1 have developed ability to experiment, process and interpret results in a way that</p> <p>will enhance systematic approach to problem-solving</p> <p>12.2 be able to use/operate scientific instruments in appropriate situations</p>
<p>13.0</p> <p>have developed scientific skills and attitudes that are necessary for self-employment</p>	<p>13.1 be able to relate scientific knowledge and skills to the business world</p>
<p>14.0</p> <p>have developed awareness and appreciation of the role of science in everyday life including the Basotho's forms of knowledge (culture)</p>	<p>14.1 be able to <i>identify</i> and apply the scientific knowledge and skills outside the classroom</p> <p>14.2 be able to identify and interpret the relationship between science and the Basotho's forms of knowledge</p>
<p>15.0</p> <p>have acquired scientific knowledge, skills and attitudes necessary for effective participation in social issue and activities</p>	<p>15.1 be able to identify and solve problems closely related to science</p> 
<p>16.0</p> <p>have developed the scientific knowledge, skills and attitudes that would enable them to adapt to and influence the scientific, technological and socio-economic changes</p>	<p>16.1 be able to apply scientific method for gathering necessary information for designing items that can be produced</p> <p>16.2 be able to produce an item from an original design (blue print)</p> <p>16.3 be able to identify and solve problems using the scientific method OR be able to observe, analyse and interpret data collected to solve problems in everyday life</p>
<p>17.0</p> <p>have developed the scientific knowledge, skills and attitudes that would enable them to adapt to and influence the scientific, technological and socio-economic changes</p>	<p>17.1 be able to identify and interpret the influence of technology on the socio-economic aspects of life</p>

C. Learning outcomes on waves, electricity and pressure

Learning outcomes (waves). At the end of Form A students should be able to:	Content
state examples of waves	types of waves: sound, water, electromagnetic waves
identify producers and detectors of waves	Producers of waves: X-rays, radio, transmitter, sun hot objects, radioactive substances, microwave oven. detectors of waves: photographic film, aerial, satellite
describe waves as longitudinal and transverse	longitudinal wave-sound transverse waves-water wave
state types of electromagnetic waves	radio waves, microwaves, infra-red rays, visible light, ultra-violet, x-rays and gamma rays)
identify uses of electromagnetic waves	uses of electromagnetic waves parts of electromagnetic waves
relate ultrasonic and use of ultra sound scanner to audible and inaudible frequencies	detection of ultra sound and ultra sonic sound
Learning outcomes (electricity). At the end of Form A students should be able to:	Content
describe the structure of a simple electrical cell	simple cell structure: electrodes and electrolyte
identify types of electrical cells	types of cells as primary and secondary and classes as wet and dry cells
illustrate simple circuits	simple circuits: bulbs and cells
identify electrical hazards	electrical hazards
connect a 3-pin plug	connecting 3-pin plug
state safety precautions associated with electricity	safety precautions against electricity
Learning outcomes (pressure) At the end of Form A students should be able to:	Content
relate amount of pressure to the difference in height	effects of fluid pressure: increase of pressure with depth,
describe activities showing that pressure at the same depth acts	fluid pressure at the same depth acts equally
relate pressure acting in fluids to depth	unit of pressure as mm/cm of water
describe activities showing effects of changes in fluid pressure	application of fluid pressure in everyday life-as in elevation, hydraulics, car brakes, filling up of tubes with fluids, siphoning

D. Scope and sequence chart.

Topic	Form A	Form B	Form C	Form D	Form E
Pressure	<p>Fluid pressure:</p> <p>Measurement and units.</p> <p>Factors affecting pressure.</p> <p>Applications of pressure.</p> <p>Effects of change in pressure.</p> <p>Experiments to show how fluid pressure is affected by depth.</p> <p>Pressure at the same depth acts equally in all directions</p>	<p>Solid pressure:</p> <p>How pressure changes as force and area change.</p> <p>Unit of pressure</p> <p>Applications of solid pressure</p> <p>Calculation of solid pressure.</p> <p>Deduction of unit of pressure.</p>	<p>Fluid Pressure:</p> <p>Calculation and application of fluid pressure.</p> <p>Units</p> <p>Density of solids:</p> <p>Floating and sinking</p> <p>Calculations of density and solids</p>	<p>Fluid pressure:</p> <p>Boyle's Law: calculations and applications</p> <p>Structure and function of a manometer, barometer and Bourdon gauge</p> <p>Solve problems involving fluid pressure using $p=hg$</p>	<p>Fractional distillation of crude oil</p> <p>Functions of products of fractional distillation</p>
Electricity	<p>Simple cell structure</p> <p>Types and classes of cells: primary/secondary; wet/dry cells</p> <p>Manipulation of simple circuits with bulbs and cells</p> <p>Connecting 3-pin plug</p> <p>Electrical hazards and safe use of electricity</p>	<p>Circuit symbols: Switch, ammeter, bulb, and voltmeter.</p> <p>Manipulation of simple circuits with bulbs, cell, ammeter, and voltmeter</p> <p>Units of current: amperes, voltmeter; Volts.</p> <p>Reading of ammeter and voltmeter.</p> <p>Diagrams with bulbs, cells, ammeter and voltmeter in series connection</p>	<p>Series connection of circuits.</p> <p>Parallel connection of circuits</p> <p>Applications and everyday examples of circuits: torch, car head lights</p> <p>major project work on application of simple circuits</p>	<p>Charge flow between two points which have a difference in potential</p> <p>Current rate of flow of charge $I=Q/t$. $A=C/s$</p> <p>E. M. F</p> <p>Electromotive force energy dissipated by source in driving a charge round complete circuits.</p>	<p>Use of electricity: heating and lighting</p> <p>Electric power: PVI, $E=V/t$</p> <p>SA use of electricity at home</p> <p>Fuses and fuse rating</p> <p>Main plug</p> <p>Cost of electricity</p>

Waves	Types of waves	Light:	Light:	Light:	Ray diagrams
	Producers and detectors of waves	Uses of light	Characteristics of waves:	Electromagnetic spectrum.	Total internal reflection
	Longitudinal and transverse waves	Properties of electromagnetic waves	wave length, frequency, amplitude, audible and inaudible frequencies.	Refraction, Lenses and eye defects	Refractive index $n = \frac{\sin i}{\sin r}$
	Electromagnetic waves	Investigating the law of reflection	SI units	Sound: Relate loudness to pitch	Light dispersion
	Detection of ultra sound waves and ultra sonic sound.	Sound: Production of sound		Quality of sound	Relationship between refractive index and critical angle
		Transmission of sound through a medium		Convex: shape, focal point and length.	Use of lenses in everyday life.
		Speed of sound in air.		Concave: shape, focal point, focal length.	Hand lens, eye, camera, projector, and binoculars.
		Comparison of light and sound waves.			



Appendix 6 observation lesson transcription

Lelimo H.S. 31/08/2004

FOURTH SET OF OBSERVATIONS

SCHOOL: LELIMO HIGH SCHOOL

CLASS: FORM A6

DATE: 31-08-2004

TIME: 2.00 p.m. – 3.20 p.m.

TOPIC: ELECTRICITY

I arrived at the school ten minutes before the beginning of the lesson which I was to observe. It was lunch time and the children were sitting in groups outside classes. It was quite as though it was not lunch. I went to the staffroom where I waited for the science teacher. In the staffroom there were teachers who were chatting. When the time approached I moved towards the laboratory and on my way I met the science teacher who I was to observe. She told me that the lesson would take place in the classroom. We moved to the classroom where we found the students sitting on their desks. The teacher greeted students and asked them to collect rubbish on the floor. She then said

Teacher: last week we did some activities in the laboratory. Which activities did we do? The students responded one by one and said:

Student 1: the structure of the cell

Student 2: electrical hazards

Student 3: wiring the 3 pin plug

Student 4: safety precautions when using the electricity

Teacher: Can one of you go and draw the cell on the board?

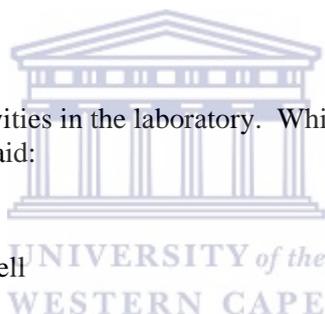
One of the students came up and drew. The second student who improved on the first structure also came up. The teacher went to the board and drew the cell.

Teacher: What is the name of the covering?

Student: It is called the zinc case.

Teacher: What about this one, pointing at the other part.

There was no response for some minutes.



Teacher: you have not done your home work. Look into your s.

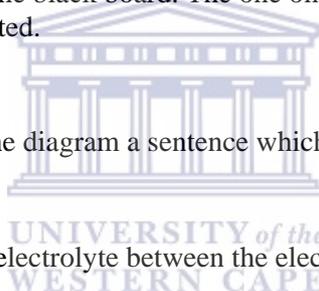
The students then labelled the parts: Ammonium chloride, powdered manganese (III)oxide and the carbon rod.

Teacher: The carbon rod and zinc case are the Electrodes, ammonium chloride is the electrolyte and powdered carbon acid manganese (III) oxide are the depolarizers.

The student: What does the carbon rod do madam?

Teacher: The carbon rod is an Electrode. For any cell to function you need two electrodes. I will be able to explain to you better when you have done the atomic structure in chemistry. Please remind me.

Teacher: Draw and label the cell on the black board. The one on the board not in the textbook since the one in the is a bit complicated.



She then wrote on the board below the diagram a sentence which read:

All cells have two electrodes and an electrolyte between the electrodes.

Teacher: Let us talk about the Electrical Hazards. What can electricity do, that is harmful?

Student: It can cause electric shock.

Teacher: How does it cause electric shock.

Student: If we put our finger in the sockets.

Teacher: That is when our bodies come into contact with wires. She then wrote on the board.

The electric shock happens when our body parts come in contact with wires which electricity is flowing.

Teacher: Does it mean we can get electric shock anytime we touch any wire?

There was some silence then.

Teacher: We can get electric shock when the wires are like what? How should the wires be for us to get an electric shock?

Student: When the wires are left bare.

Teacher: So if our body parts touch bare wires we get shock. So those wires must be bare and there should be electricity passing through them. So this is why we can touch the electric cord. The extension cords are covered. But if one comes in contact with the part of the extension cord which is bare we get electric shock.

Teacher: What do we use to cover those wires? What are the wires covered with?

Student: The plastic.

Teacher: The wires are covered with plastic or insulated with plastic.

She then wrote on the board.



Always make sure that electric cables/wires are properly insulated (with plastic).

WESTERN CAPE

Teacher: What else should we do to avoid electric shock? What should we avoid or should do in order that we do not get electric shock.

Student: We should avoid putting our fingers into the socket

.

Teacher: What else.

Student: Make sure that the plug is off before we connect cables.

Teacher: How does that avoid electric shock.

Student: So that electricity does not flow.

Teacher: Does that avoid electric shock. Under what circumstances does electric shock...?

Teacher: When you come in contact with wires where electricity is passing.

Teacher: So, Tsepo how does what you said help in avoiding electric shock.

Student: I was once shocked when I placed the appliance in the plug

.

Teacher: Were you touching the rod or the pins.

Student: The pins.

Teacher: So we should not touch the pins when connecting the plug. We should not hold the plug by the pin when putting them in the plug.

Student: We should avoid the appliances, which do not have the earth wire.

Teacher: What is the earth wire? What do we mean by earthing? What is the importance of earthing?

Silence ... may be we should leave this one we will talk about it sometime, so we should use appliances which have earth wire or which are earthed. What else can electricity do?

Student: It can paralyze a person.

Teacher: Out of the electric shock. Firstly all, the person has to be shocked then she can then be paralyzed due to shock. It may also kill you.

Student: It can cause fire.

Teacher: Under what circumstance does the electrical fire happen?

Student: When the cords are lying on the stove when the stove is on.

Teacher: Is that fire the result of electricity or due to the stove ...? But there are fires which can be caused by electricity. What would have happened?

Student: When some one has tripped over the cords.

Teacher: Let say you have connected the radio to the cord and then you trip over it.

Student: They explode and cause electric fire.

Teacher: Does it explode.

She then wrote on the board “fires due to tripping over the cable connected to the heaters or stoves or covered heaters.

How else? Suppose ... but please do not try these at home. Suppose you take two wires with electricity passing through them and make them touch what happen?

Student: If two cables meet they produce sparks.

She then wrote on the board talking. If the sparks fall on some petrol they can cause fire.

Teacher: The sparks can cause an electric fire. Again if you pull the plug out of the electric socket very fast with the socket still on what happens?

Student: You can see sparks.

Teacher: Which means we should not pull out the plug out of the socket while electricity is still on. Do we understand each other? Or you have to switch off the plug and move it out of the socket.

She then wrote: “Fires due to sparks when taking out the plug from the socket without pulling the plug.”

Teacher: Sometimes in winter when we find that we have few sockets what do we do?

Students in chorus: We overload the plugs.

Teacher: What do you mean by overloading the plug?

Student: Putting many plugs in one socket.

Teacher: So that means you should not put too many plugs on one socket. Let us say we have connected too many plugs to the socket and one of them is connected to the heater. What happens? What do we feel?

Students in chorus: heat

Teacher: They become hot; imagine what will happen if they continues to heat up. The plastic will melt so we should avoid overloading the sockets. She wrote again on the board:

Over heating of cables.

Do not over load the socket. Always switch off the socket when plugging through it. Do not connect cables which are too long to avoid tripping over them.

Student: We should not put off electric fire with water.

Teacher: Why, why not?

Student: no we can.

Students in chorus: NO

Teacher: So, why?

Student: Because electricity can pass through water.

Teacher: Then electricity will flow through water to you and you can get a shock. So we should avoid using electricity with water because water conducts electricity. You will be putting yourself at risk.

The students were discussing among themselves.

Student: Bare wires should not be inserted in the sockets.

Teacher: So do not insert bare wires in electric sockets.

She wrote this statement on the board.

Student: Madam can I ask? How does the shock which I get when I touch
Lintle differ from the electric shock?

Teacher: What is the difference? Who has experienced the two types of electric shock?
The one in which you touch a person and say the person has shocked you and the
one you get from touching electricity.

Student: One of you is lacking nutrients.

Student : One of you is charged and the other is positive.

Teacher: How are they different?

Student: What I get from the electricity is more powerful than the shock you
get when you touch a person.

Teacher: Yes, the other one is weak but they are still the result of electricity.

We have what we call ... We have two types of electricity, current electricity
and static electricity. Static electricity is the one if you remember, we get when
doing types of forces and the pen picked some pieces of papers. But current
electricity is the one that flows through the wires like the one we did with the
circuits in the laboratory. Basically all these shocks are the result of electricity.

Teacher: Any other question.

Student: Can electricity destroy the environment.

Students in chorus: Yes.

Teacher: How?

Students: If any house is burned it can cause fire to other houses.

Teacher: In this case we have an electric fire which can destroy the environment.

Student: Is it better to use metal poles or wooden poles?

Teacher: What is our view as a class?

Students in chorus: Wooden poles, because electricity can pass through metals.

Teacher: Yes, because electricity can pass through metals. But have we noticed that the pole that carry electricity from 'Muela (long distance) are made of metal. How have they been modified so that they are not dangerous?

Student: The wires are not in contact with the poles they are separated by insulators. They are insulated.

Student: Madam, how should we put off the electric fires if we do not use water?

Students in chorus: So!

Teacher: They are say so! But the first thing is to put off electricity before attempting to put off fire. There are main switches which you usually say it has fallen in the house. That is where you should switch off first. It is just like the shocked person. Before you attempt anything put off the electricity.

Student: Madam, what should be the first thing to do before taking a person with a shock to hospital?

Teacher: Remove the person from electricity and follow the usual first aid. If the person is running out of breath then you use mouth to mouth resuscitation. If the person is burned use basic first aid of wounds.

Student: I thought we were always going to die if we get electric shock.

Teacher: No, but it is dangerous.

Teacher: So today we have learned a lot about electricity. I would like to tell you that electricity is very dangerous. We should avoid playing the radio by placing wires into sockets and lights. That is very dangerous. You have to see that some plugs do not have covers. We should not remove coverings.

Then the class ended. On our way to the staffroom I discussed the lesson preparations with the teacher. I had suspected that she might have forgotten to discuss the wiring of the electric plug. She told me that she never has formal preparations of the lesson than writing down what she will be doing in the lesson. I needed her written preparations. She further told me that she admits written preparations bring flavour to her lessons but she thinks it boring. I asked her about the scheme and she said she would do that one later if there is chance. She also indicated that she works more on her lessons if she thinks they did not go well on a particular year but otherwise her lessons are very similar to those of the previous year.

Impressions

A lot of everyday life issues about electricity transpired in this lesson. But does one see integration? The cell was an issue. The electrical hazards are ... So what? Each is a content area? But at the end of the day she is working towards achieving the objectives of the syllabus. Discussion of everyday life issues? No So what?