MALAWIAN SECONDARY SCHOOL STUDENTS' LEARNING OF SCIENCE: HISTORICAL BACKGROUND, PERFORMANCE AND BELIEFS

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A thesis submitted in partial fulfillment of the requirements of the degree of Doctor of Philosophy in the Department of Mathematics and Science Education, University of the Western Cape

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KEY WORDS

Education

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Constructivism

African students

Mixed methods

Learning skills

Students

Epistemological beliefs

Metacognition

Self-regulation

ABSTRACT

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This study explored the problem of poor performance in science among students who are provided secondary school places on merit in Malawi. Existing studies of the problem are inconsistent suggesting that these studies may have shed light on some parts of a complex problem. Questionnaires, interviews and analysis of documents were used to obtain information concerning students' conceptions of science, science learning and events that eventuated into the problem in the past.

The population for this study was 89 government and government-assisted secondary schools. From that population eighteen schools were randomly selected from each of the six education divisions in the country. One thousand five hundred secondary class 3 students drawn from randomly selected schools participated. The participating students completed a 31-item learning beliefs and practices questionnaire with items drawn from the science education literature and adapted to the local situation and a self-efficacy and attribution of failure questionnaire. Forty students were interviewed about their concepts of science and science learning. Relevant documents found in the Malawi National Archives were analyzed to determine the origin of the problem.

The major findings were: (1) Malawi in the late 1940s adopted a lower level of performance of its students compared with her Eastern neigbours in the sense that it made no effort to improve performance of its students in the Makerere Entrance Examinations; (2) performance of students in physical science is not only poor but also deteriorating with time; (3) students have high positive academic self-efficacy in learning physical science; (4) listening and reading are the most common learning skills that students use in learning physical science; (5) students attribute poor performance of students in physical science mainly to factors other than themselves; (6) the downward trend in the performance of student on Malawi was foreseen by the Colonial Office in London; (7) students indicated a very low level of involvement in their learning in the sense that most of them did not know the prescribed books for preparing for the examination in physical science.

These findings led to the following conclusions: (1) poor performance of students in Malawi arose from of the Department of Education's failure to raise the quality of students' work to the standard required for admission into Makerere College in the late 1940s and early 1950s; (2) students in Malawi have in the past performed poorly in other subjects other than science; (3) although the students are selected on merit they nevertheless have little knowledge of learning skills that they can use to learn physical science. Recommendations for improvement are discussed in the thesis.

DECLARATION

I declare that *Malawi Secondary School Students' Learning of Science: Historical Background, Performance and Beliefs* 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.

Emmanuel Nafe Novel Dzama November 2006

Signed……………………….

This thesis is dedicated to the loving memory of my dear mother and father who never lived to witness this work

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CONTENTS

CHAPTER TWO

DIGGING UP THE STORY OF THE PROBLEM

CHAPTER FOUR

THEORETICAL AND CONCEPTUAL FRAMEWORK

CHAPTER FIVE

REVIEW OF THE LITRERATURE

CHAPTER SIX

RESEARCH DESIGN, METHODOLOGY, METHODS AND PROCEDURES

CHAPTER SEVEN

RESULTS: PRESENTATION AND DISCUSCUSSIONS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

ALN	**Asynchronous Learning Networks**
CASE	**Cognitive Acceleration through Science Education**
CDSS	**Community Day Secondary School**
CO	**Colonial Office**
COSCE	**Cambridge Overseas School Certificate Examiation**
DC	**Developing Country**
Dep. Ed. Rep	**Department of Education Annual Report**
DRCM	**Dutch Reformed Church Mission**
EFA	**Education for All**
EQAO	**Education Quality and Accountability Office**

ESOL	**English to Speakers of Other Languages**
FPEP	**Free Primary Education Program**
GASAT	**Gender Science and Technology**
GGASS	**Government and Government Assisted Secondary Schools**
GPA	**Grade Point Average**
HLM	**Hierarchical Linear Modeling**
IEA	**International Assessment of Educational Achievement**
IC	**Industrialized Countries**
IE	**Instrumental Enrichment**
IT	**Information Technology**
ITED	**Iowa Test for Educational Development**
JCE	**Junior Certificate of Education**
MANEB	**Malawi National Examinations Board**
MLE	**Mediated Learning Experiences**
MSCE	**Malawi School Certificate of Education**
MSLQ	**Motivated Strategies for Learning questionnaire**
NELS	**National Educational Longitudinal Study**
NOS	**Nature of Science**
PISA	**Program for International Student Assessment**
POE	**Predict Observe Explain**
PSLCE	**Primary School Leaving Certificate Examination**
PTTC	**Primary Teacher Training College**
RSPM	**Raven's Standard Progressive Matrices**
SADC	**Southern African Development Community**
SACMEQ	**Southern and East African Consortium for Monitoring Educational Quality**

SAT	**Standard Achievement Test**
UNESCO	**United Nations Educational Scientific and Cultural Organization**
USA	**United States of America**

LIST OF APPENDICES

Chapter 1

Motivation and background

1. Introduction

This study explored the problem of poor performance in physical science in national examinations among secondary school students in Malawi. Although this problem is commonly found in many countries, it is peculiarly acute in Malawi as indicated later in this thesis. This introductory chapter provides an overview of the study. The chapter is organized into eight sections. In the first section motivation for doing the study is presented. The problem that was investigated is stated in the second section. Then follow research questions, general orientation to research questions, rationale and purpose and importance of the study, theoretical and conceptual framework and the author's pre-research perspective in sections three to seven, respectively. The last section provides a synopsis of the study.

1.1 Motivation for the study

I have been aware of the problem of poor performance in physical science among secondary school students in Malawi since I started teaching science as a qualified teacher, in 1976. I happened to have gone to a secondary school where performance of students was relatively good compared to other secondary schools. Development of my awareness of the problem is divided into three phases namely: early phase, middle phase and tertiary phase. These phases and subsequent refinement of my understanding of the problem –poor performance in physical science among secondary school students, are presented in this section seriatim.

1.1.1 Problem in early phase

I first noticed the problem of underachievement of students in science in the late 1970s while teaching Physical Science at secondary school in Malawi. My investigations of the problem at that time revealed that some of the girls in my classes had not done science and health education in standard 8. During that time, policy in primary schools required girls in standard 8 to study either home economics or science and health education. Female students were not allowed to study both subjects. The girls who had studied home economics at primary school lacked prerequisite knowledge for successful learning of physical science. The physical science curriculum at secondary school assumed coverage of science and health education syllabus at primary level. Whereas poor performance in science among girls could be plausibly explained in terms of their not taking science and health education in standard 8, poor performance among boys could not be similarly explained, since all boys studied science and health education in standard 8. I strongly felt, though, that the effort I was making in teaching physical science deserved better success at national examinations than my students were achieving.

1.1.2 Problem in middle phase

The middle phase in my understanding of the problem started in 1988 when I joined the University of Malawi as a lecturer in physics education. During this phase I was exposed to the works of Odhiambo, Jegede and Levy-Bruhl (Odhiambo, 1972; Jegede, 1990 and 1995; Cazeneuve, 1968). In summary, Odhiambo (1972) appears to have applied Levy-Bruhl's thesis to the problem of poor performance in science among Africans, although he does not explicitly state this. Levy-Bruhl's original thesis published in French in 1926 held that primitive people like Africans had no sense of cause and effect and were incapable of distinguishing logical from non-logical procedures (Lowie, 1937). Malinowski (1948), Dougall (1932) and Douglas (1975) have presented summaries of Levy-Bruhl's thesis that concur with Lowie's (1937) summary cited previously. Levy-Bruhl and Odhiambo share the perception that Africans are monistic. Odhiambo uses monism to explain poor performance in science among African students (Odhiambo, 1972, p. 45). Monism is a philosophical theory, which claims that all reality is one and that the plurality of things in nature is an illusion. Pluralism, on the other hand, is the contrary view to monism. Pluralism holds that all reality is multifaceted (Dzama and Osborne, 1999). Odhiambo (1972, p.

45) considered Africans' monistic world-view to be the "basic root of the problem" of poor performance in science. In his view, Africans' lack of sense of cause and effect made it impossible for them to create knowledge through hypothesis formulation. He laments that Africans' inability to use hypotheses to generate knowledge is "perhaps the most serious gap between Africans' world-view and Western science" (Odhiambo, 1972, p. 45).

On the issue of Africans' ability to distinguish cause from effect, Jegede (1990) claims that in African societies every event has a cause that is interpreted in personal terms. The personal terms used to interpret events in African societies include other human beings, ancestors, spirit, or god (p. 8). Jegede argues that Africans are anthropomorphic in the sense that they ascribe causes of events to other humans or to human-like things such as ancestors or gods. According to Jegede the problem of poor performance in science subjects among African students originates from their anthropomorphic worldview.

The central argument of Odhiambo and Jegede is that the African has a worldview that cannot facilitate success in learning science (Dzama and Osborne, 1999). Levy-Bruhl the author of the ideas that are seemingly used by Odhiambo and Jegede was, however, his own revisionist. In papers that were published posthumously he indicated that he was prepared to give up the term "prelogical" in describing the mentality of primitive people. He also stated that he could not justify the specificity of the characteristics he had attributed to primitive mentality (Cazeneuve, 1968, p. 265).

Dzama and Osborne (1999) reacted to the use of Levy-Bruhl's abandoned ideas in discussing the poor performance in science problem among Africans. These authors argued following Elkana (1977) that the tendency to make causal explanations is a universal feature of human thought (Dzama and Osborne, 1999). The authors used pre-colonial African folk stories to demonstrate hypothesis formulation and search for causes of events among Africans. In their paper Dzama and Osborne (1999) further argued that Africans may be monistic or anthropomorphic in their religion, in everyday life, however, flashes of pluralistic and mechanistic thinking colour their lives. The authors conclude that commitment to learning science is a product of necessity rather than desire (Dzama and Osborne, 1999). To demonstrate that it is necessity rather desire that fosters development of science and technology in nations, the authors examined the development of science in England, India and Japan highlighting the role played by the First and Second World Wars in facilitating institutionalisation of science in these countries.

1.1.3 Problem in tertiary phase

The tertiary phase began in 2001. Since the publication of our study (Dzama and Osborne, 1999), I have developed three insights into the problem of poor performance in science. These insights are presented in the following paragraphs.

The first insight occurred to me incidentally as I was collecting materials for history of science in Malawi. While collecting the historical materials, I found that the problem of poor performance in science among secondary school students in Malawi is as old as the secondary school system in the country. I found that the problem was noted for the first time in 1942, by examiners from Makerere College and was reported in the Department of Education Report in 1942 (Dep. Ed. Rep., 1942). I also found that other scholars had grappled with the problem of poor performance in science among Malawian students. Phillips Commission, for instance, found that in Malawi students who took general science in their school certificate examinations ended up doing poorly in their Advanced level examinations (see Phillips, Esua, Larby and Baily, 1962). General science, according to the Commission, did not provide a sustainable foundation for the study of physics, chemistry and biology as separate subjects at Advanced level hence the poor performance of the students. General science is a combination of physics, chemistry and biology as one subject.

Similarly, in deliberations held at University College of Rhodesia and Nyasaland in 1963, the Leverhulme Inter-University Conference concluded that the background of African students was the main cause of poor performance in science subjects (University College of Rhodesia, 1966). The Conference cited two factors in the background of African students that impede learning in the sciences. These factors are: lack of general mechanical and scientific experience in childhood and cultural traditions of myth and witchcraft. The conference further pointed out that the necessity of teaching science in a second language also contributed to poor performance among African students.

This study acknowledges the possible inimical effects that the cited factors may have on learning science among African students. The study, however, focuses on the quality of individual learning of physical science. It assumes with the Phillips Commission (Phillips *et al*., 1962) that if primary schools' products are generally poor learners, then, regardless of mode of selection into secondary school, such learners will continue to be poor learners in secondary schools, if their approaches to learning are not changed for the better. Selection to secondary school does not convert poor learners into good learners. What needed to be done according to the Phillips Commission was to raise the general quality graduates from primary schools to ensure successful work at secondary school level. The recommendation of the Phillips Commission was, however, rejected in preference to the recommendation of the Johnson Survey Team. Johnson, Blake, Porter and Twum-Barima (1964) advised the government to concentrate on developing secondary education. The apparent thinking of the Johnson Survey Team seems to have been that selection on merit would ensure that only good learners would proceed to secondary schools. The persistence of the poor performance in science among highly selected students begs the question of the correctness of the thinking of the Johnson Survey Team concerning the quality of students selected to secondary schools in the country and is the *raison d'etre* of this study.

This study assumes that besides learning science content, students should also learn about the nature of science and how to learn science. What students do to learn physical science for instance, depends on their conceptions of science and learning. Duit and Treagust (1998, p. 8) state, in this connection, that at the heart of the constructivist view of learning is the idea that "conceptions held by each individual guide understanding". Students' conceptions of science and science learning are derivatives of their prior learning experiences. What students actually do to facilitate learning of physical science is used in this study to determine what the students know about science and science learning. What students know about science and science learning, in turn, reflects the quality of teaching and learning they have had. In focussing on prior school learning experiences, the study draws on Brooks and Brooks (1993) who maintain that poor performance among students is a reflection of the manner in which students were taught.

The second insight that changed my perception of the problem of poor performance in science occurred to me while reading the autobiography of Henery Chipembere, a former student of Blantyre Secondary School, Malawi's first secondary school. My purpose for reading Chipembere's autobiography was to find out more about science education during the infancy of Blantyre Secondary School. Chipembere had a successful academic and political career that culminated in his being appointed minister of education. In his autobiography, he demonstrates awareness of the problem of poor performance in science and mathematics. He writes:

> I was at an advantage, however, as far as arithmetic was concerned, for in this subject the Tanzanian schools did much better than Malawian schools. Many years later, I was to notice that Tanzanians did much better than Malawians in the Cambridge Overseas School Certificate Examination in mathematics and science. It seems that once certain traditions have been established by the colonial regime, they persist many years afterwards even after a change of rulers (Chipembere, 2002, p. 73-74).

In the excerpt above Chipembere appears to say that because he got his early primary education in Tanzania where arithmetic was taught better than in Malawi, he had no problems in learning arithmetic when he came back to Malawi. Examiners from Makerere College in Uganda support Chipembere's position when they state that Malawian students were poor in science and mathematics (Dep. Ed. Rep, 1942). If poor performance in science is a consequence of traditions established by missionaries and colonial administrators, as Chipembere suggests in the excerpt above, what is the nature of these traditions? Were the traditions established accidentally or deliberately? Such questions as these guided the conceptualisation of this study.

The third insight developed from two quotations found in the literature. Hotano is quoted in Heller (1993, p. 50) as saying "For science and mathematics, practice is done outside school". On the other hand, (Shuell, 1986, p. 429) holds that "what the student does is more important in determining what is learned than what the teachers do" (Shuell, 1986, p. 429). If practice of science is done outside class or laboratory periods, would examining what students do in science after classes provide fresh clues to the poor-performance problem? Is performance in science and mathematics different from performance in English because of the different ways in which these subjects are studied? These were some of the questions that this study grappled with at its conceptualisation stage.

1.1.4 Refinement of my understanding of the problem

A number of studies of the problem of poor performance in science have been done in Malawi (Case, 1968; Kimball, 1968; Kamwendo, 1984; Dzama, 1985; Kunje, 1988; Mitchell, 1993; Dzama and Osborne, 1999; Mbano, 2003). Factors that contribute to the problem have been identified. These factors include: language of instruction; negative attitude to science; lack of equipment for science teaching; mismatch between level of cognitive development of students and cognitive demands of science syllabuses; school curricula that are not relevant to the needs of students and absence of environments that are conducive to learning science. None of these studies, however, has investigated the manner in which students learn the content that is presented to them in science classes. To my knowledge, no study has researched the epistemological beliefs that children in Malawi have about science and learning science.

Some scholars consider such variables as African culture, African worldview and lack of science related jobs (Ezeife, 2003; Ogunniyi, 2002; Ogunniyi, Jegede, Ogawa, Yandila and Oladele (1995), Aikenhead and Jegede, 1999; Dzama and Osborne, 1999; Waldrip and Taylor, 1999) as factors affecting students' performance in science. The findings of these studies, however, cannot be used to explain the difference in science and mathematics performance between for example, Malawian and Tanzanian students as reported by Chipembere (2002). The colonial administrators were the first to conclude that poor performance of students in science and mathematics in Malawi was "a handicap that secondary schools had inherited from primary schools" (Dep. Ed. Rep., 1942, p. 6). They considered poor teaching of science and mathematics in primary schools to be a major factor in determining the performance of students at secondary school level.

In the post independence period in Malawi (1964 onwards), primary schools appear to have been absolved from any responsibility for poor performance of students in science and mathematics. Of the studies that have been done to understand the problem, none has focused on primary education. As Peacock (1995) suggests, primary education tends to be neglected. African scholars have since the late sixties emphasized the role of culture and worldviews in their thinking of the problem of poor performance in science (Odhiambo, 1972; Jegede, 1990, 1995). It is the African worldview and culture that are considered to be responsible for poor performance in science and mathematics. The Phillips Commission's thesis proposed that students selected from a group of poor learners at primary school level are unlikely to succeed in their learning at secondary level. For Malawi, there are three reasons for following up on this thesis. These reasons are presented in the following paragraphs.

Reasons for following up the thesis of Phillips Commission

The first reason is that since independence the country has witnessed little change in science curricula and teaching methods. At independence in 1964, Malawi contracted United Nations Educational, Scientific and Cultural Organization (UNESCO) experts to develop a primary school syllabus for the country. The experts produced the 1966 Primary School Syllabus (Malawi Government, 1966). This syllabus offered nature study to students in standards 1 to 4 and general science to those in standards 5 to 8. In many respects the syllabus was an improvement over the 1961 syllabus. Among new topics included in the 1966 syllabus were: the meaning of science, achievements and aims of science; and the utility of science in agriculture, medicine, transport and energy supply (Ministry of Education, 1966, p. 63). Unlike the 1961 primary school syllabus that offered primary school children rural science, the 1966 syllabus offered general science. It also required Standard 8 students to carry out research projects in groups of 4 or 5. Rural science was a mixture of agriculture and environmental studies and general science was a mixture of physics, chemistry, biology, agriculture and earth sciences. Commenting on the 1966 syllabus, Kachama (1972, p. 3) writes:

> We do hope that the effects of these new (primary science) approaches at the secondary level will be an increasing number of pupils endowed with inquiring minds; pupils who are prepared to ask questions and who are not always ready to accept answers; pupils with a need for stimulation and possessing a lot more understanding of basic concepts than was hitherto the case. The secondary school teacher will have to adjust to this kind of pupil when he first comes into Form 1

The kind of secondary school student that Kachama describes in the excerpt above never reached secondary class 1 in Malawi. Hawes (1979) points out that there was underlying conflict between the aims of the science curriculum and the intention of the political elite to produce citizens who would obey without asking questions

(Dzama, 2003). This conflict was resolved in 1972 through a Presidential announcement that forbade the use of "modern methods" in education (Hawes, 1979, p. 53). After the announcement, teachers were forced to revert to methods and materials that were used during the colonial period. Children were instructed to obey without asking questions. Although the 1966 syllabus was withdrawn immediately after the then President's announcement a new syllabus was produced ten years later in 1982.

In 1982 a new syllabus adapted from the 1961 primary school syllabus was introduced (Malawi Government, 1982). The 1982 syllabus excluded all topics concerning the nature of science and scientific investigations. It also dropped the requirement for Standard 8 students to do project work. The most serious blemish of the 1982 syllabus was that it combined science with health education to constitute one subject called science and health education. This combination has had the effect of reducing the time available for teaching science in primary schools in Malawi by half. Science and health education was allocated four periods per weak with explicit instruction that, science should be allocated 2 periods per week and health education should also be allocated 2 periods per weak.

In the 1966 primary school syllabus, health education was combined with physical education. Science and health education demand different teaching and learning approaches. Combining the two created the possibility that one subject could over shadow the other. Since science has had a long history of poor performance in Malawi, combining it with health education on a one to one basis was an unreasonable action. Because knowledge of the nature of science is not an explicit component of the 1982 syllabus, students in Malawi's primary schools may not develop understanding of the nature of science. Similarly the students are unlikely to develop appropriate methods for learning science. Combining science with health, gardening or home economics was a way of ensuring that Africans would not learn much science during the colonial period. In their book, *Education and Colonialism*, Altbach and Kelly (1978, p. 14) note that in the colonial era science became "instruction in domestics and personal hygiene at primary level and practical and applied sciences…at post-primary level". Domestics and personal hygiene constitute half of the current science and health education syllabus. Conditions that prevailed in the colonial period seem to have been perpetuated into the post independence period. Would students learning in these conditions develop sustainable understanding of science and appropriate learning skills for learning it? This study assumes that they would not and sets out to find out the truth or falsity of this assumption.

The second reason is that throughout the post-independence period, studies done in Malawi and elsewhere suggested that something else is wrong with primary education in the country. For instance Kimball (1968) compared school and non-school going children with respect to development of concept areas that were considered important in understanding science. The conceptual areas tested included basic electrical circuits, balancing and, cause and effect. He administered tasks to school and non-school going children in schools and markets in Malawi and found no difference between the two categories of children. This finding implied that the education that children received in primary schools made no difference to the students' cognitive development in the tested areas.

Similarly, Heyneman (1980) provides evidence of the peculiar nature of Malawian primary school students. He administered achievement test items in science and reading to randomly selected students. The items that were administered to students in two districts in Southern Malawi were drawn from items of the first study of the International Assessment of Educational Achievement (IEA). Heyneman found that in reading comprehension, the performance of Malawian students was 27% below the mean score for Developing Countries (DC) and 50% below the mean score for Industrialised Countries (IC) (Heyneman, 1980, p. 11). A recent study of literacy in Standard 6, Milner, Chimombo, Banda, Mchikoma (2001) supports Heyneman's (1980) finding about poor literacy levels among primary school students. Milner *et* *al.* (2001) carried out a national survey of literacy among Standard 6 students. They found that only 0.6% of their stratified and randomly selected national sample of Standard 6 students were able to read at the desired level as determined by reading experts in the country. A comparative study of literacy for grade six primary school students conducted by the Southern and Eastern African Consortium for Monitoring Educational Quality (SACMEQ) concurs with Milner *et al.* (2001). It found that the average scores of Malawian students are the lowest among the seven countries that participated in the study (UNESCO, 2004, p. 121). Literacy in the language of instruction is indispensable to science learning. Osborne (2002, p. 206) succinctly captures the importance of literacy in science education "For just as there can be no houses without roofs or windows, there can be no science without reading, talking and writing".

In the preceeding quotation Osborne suggests that literacy in the language of instruction is constitutive of science learning itself. Other scholars have expressed similar (Lemke, 1990; Sutton, 1998; Hand, Prain, Lawrence and Yore, 1999 and Yore, Bisanz and Hand 2003). It seems that students who are poor in general literacy are likely to perform poorly in science subjects.

Although there may be causal links between poor performance in science and the factors and events described previously, this study does not assume existence of any such links. My aim in describing the foregoing events and factors is to underline the need for a thorough investigation of the manner in which students in secondary schools learn physical science rather than to suggest possible causes of the problem. My argument is that, given the circumstances in which the students learn the likelihood of their developing adequate knowledge of the nature of science and the likelihood of their acquisition of appropriate skills for learning it are minimal. The timeliness of the study is vindicated by Mbano (2001, p. 284) who recommends carrying out "A study of the kinds of learning that go on in Malawian schools". She refers, in this regard to the need to investigate the manner in which students in Malawi learn science. Investigation of what students do to learn the science content that is presented to them during lessons, is one of the tasks that was undertaken in this study.

The third reason is a practical one. The problem of poor performance in science subjects in Malawi calls for a solution that can be implemented in the short run. Studies in African culture, African worldview or border crossing are unlikely to provide such a solution because of the difficulty involved in changing worldviews or cultures. In addition, these studies approach the problem from the teacher's side of the teaching and learning equation. The emphasis is on teaching rather than learning. The studies seek to determine what teachers can do to facilitate learning. The emphasis in this study is on what students do to learn science and develop their mental competence. This study concurs with Mintzes and Wandersee (1997) that that substantial breakthroughs in science education will need to focus more on the learning side of the equation. In their view, these authors claim that efforts to improve science teaching are rapidly approaching a point of diminishing return (Mintzes and Wandersee, 1997). In similar vein, Barba and Reynolds (1998, p. 928) allude to the importance of investigating students' learning when they maintain that success in science classrooms depends "not only on what schools and teachers do, but on what students do". This means that in the search for new knowledge to improve science education, due attention should be directed at what the students do to learn science.

Furthermore science education scholars of the worldview-culture persuation call for development of new science courses derived from the students' environment and culture or for sugar coating of Western science with traditional cultures (Ezeife, 2003; Odhiambo, 1972). These recommendations are not acceptable to me because they amount to changing the job so that the workers may experience some success. My job has been to teach Western science and in this study I am seeking ways of improving the learning of Western science. Admittedly, science courses based on local environments are necessary for all the students. Such courses, however, should not be taken to be substitutes for courses meant to prepare students for university education in the sciences or for entry into science based professional training institutions. The following section presents a statement of the research problem that the study attempted to find solutions for.

1.2 Statement of the problem

In the previous section I have presented the development of my knowledge of the problem of poor performance of students in science. I have also presented studies and events that suggested to me the need to investigate the manner in which students in Malawian secondary schools learn physical science. In this section, I state the problem that was investigated in this study.

Bereiter (1990, p. 608) tells us that schools exist because some important kinds of learning are difficult in the sense that "most people are unable to learn them without help". The basic function of schools is to help students in their learning of prescribed content and skills. Poor performance of students in national examinations simultaneously reflects failure of students in their learning of content and skills presented to them, and failure of schools in facilitating students' learning. Many factors account for the success or failure of students in their learning. In Malawi, perennial mass failure of students in national examinations in physical science is symptomatic of the existence of a problem or problems that need to be addressed. The exact identity of the problem(s) is not yet known. As indicated previously, the colonial administrators speculated that the problem was inherited from primary schools (Dep. Ed. Rep., 1942, p. 6).

In their article concerning the relationship between study strategies and learning outcomes, Van Rossum and Schenk (1984) seem to offer a clue to the identity of the problem. They argue that traditionally in studying human learning emphasis has been placed on learners' understanding and grasp of the content and skills presented to them in class instead of the way learners function when performing learning tasks. The authors refer to studies of human learning in which the focus is on learners' description or reproduction of different aspects of reality as studies done from a "first order perspective" (van Rossum and Schenk, 1984, p. 73). In their formulation studies focusing on the way learners function when performing a learning task are "second order perspective" (van Rossum and Schenk, 1984, p. 73). These authors suggest that studies of human learning should be done from a second order perspective. Most of the studies that have been done about poor performance in science in Malawi have been done from first order perspective.

Some African scholars have shown awareness of importance of focusing research on learning in schools on learners understanding of concepts of learning and on their perceptions of science learning tasks presented to them in class. The rift between learners' conceptions of learning and the ideas of learning embedded in science curricula is considered to be one of the factors that account for poor performance in science. Peacock (1995) for instance, argues in this connection, that the perceptions of learning that are traditionally held by parents, teachers and school children in most African countries are different from the concepts of learning that are embedded in science curricula in these countries. Similarly Ogunniyi (1986) considers poor study habits and preference for rote learning rather than problem solving to be some of the factors affecting achievement of students in science subjects in Africa. In spite of the common awareness of the importance of perceptions of science learning and study habits little has been published about students' perceptions and approaches to learning science in African countries. One searches the available science education literature in vain for studies on how African students learn things that are presented to them in class. Shuell (1986) states that what students do matters more than what teachers do. If practice in learning science is done outside school hours as Hotano (cited in Heller 1993) maintains, then it is imperative that a study of how students learn science and enhance their mental competences be conducted in the search for clues to the poor performance in science problem.

Specifically, this study explored the question: What are the individual learning-related factors that keep highly selected students in Malawi from performing at their expected levels in national examinations? This problem is translated into research questions in the next section.

1.3 Research questions

The aim of this study is to explore the problem of poor performance in national examinations in physical science. For the purpose of study the research problem was broken into one general question and five specific questions. The general research question is: What are the individual learning-related factors that keep highly selected students in Malawi from performing at their expected levels in national examinations?

To guide the investigation the following research questions were posed:

1. How have students performed in science subjects in national examinations in the past?
2. What perceptions of themselves, as learners of science, do the students have?
3. What epistemological beliefs about science and science learning do the students have?
4. What learning skills do students use when learning science after class hours?
5. What self-regulatory skills, if any, do the students use when learning physical science?
6. To what do the students attribute their failure in physical science?

1.4 General orientation to research questions

Georghiades (2000) states that conceptual change learning based on the Piagetian constructivist view of learning and epistemological considerations of science and science learning have been the predominant paradigms in science education in the past 25 years. To these paradigms one could add social cognitive theories of learning. This study explores the problem of poor performance in science in national examinations in Malawi through inquiry into six issues that are considered to be related to the problem. The issues are: history of the problem of poor performance in science in Malawi; self-efficacy beliefs among the students; epistemological beliefs about science and science learning held by the students; learning skills used by individual students in learning science; meta-cognitive and self-regulatory learning skill; motivation; and, students' attributions of success or failure. These aspects of the study are commented upon briefly in the following section.

1.4.1 History of the problem of poor performance in science in Malawi

The inclusion of a historical dimension, in a study of a present day problem; necessitates a brief explanation. A fuller understanding of the problem requires an examination of the original circumstances in which the problem arose. A study of the original circumstances in which the problem was noted for first time is a historical study. Such a study involves location, evaluation and synthesis of evidence to be used in establishing facts and drawing conclusions about the problem (Cohen, Manion and Morrison, 2000). The value of historical studies in facilitating understanding of present day problems in education is widely acknowledged in the literature (Fraenkel and Wallen, 1993; Brickman, 1979). Cohen *et al*., (2000, p. 159) argue that historical research of an educational problem can "yield insights…that could not be achieved by any other means". Similarly, Layder (1993, p. 173) adds that "historical analysis can add depth" to a research of a present day problem. Furthermore, a study of the history of a problem enhances sensitivity to the context in which the problem arose. This study has included the historical dimension in its search for insights that would facilitate better understanding of the problem because the problem itself has a history. The research question in this connection is: *How have students performed in science subjects in national examinations in the past*?

1.4.2 Perceptions of themselves, as learners of science

Students' perceptions of science, science learning and of themselves as learners of science are known to affect their achievement in science. Students' perception of themselves, as learners of science, is part of their academic self-efficacy. Academic self-efficacy is an aspect of personal self-efficacy. Bong (2002, p. 133) defines academic self-efficacy as "the individual's convictions that they can successfully carry out given academic tasks at designated levels". Academic self-efficacy like personal self-efficacy is derived from past experience (Bandura, 1997; Bandura, Barbaranelli, Caprara and Pastorelli, 1996). In his social cognitive theory, Bandura (1997) stipulates that people's judgements of their capabilities strongly influence the choices they make, the effort they expend, and how long they persevere in the face of challenge (Bandura, 1997). The theory claims that "if people believe that they can control the outcome of their behaviour, then they can" (Franzblau and Moore, 2001, p. 83). It is thus necessary to find out whether students think they can succeed in learning physical science. The research question in connection with students' perceptions of their self-efficacy beliefs is: *what perceptions of themselves, as learners of science, do the students have?*

1.4.3 Epistemological beliefs about nature of science and science learning

Epistemological beliefs are individual's understandings about the nature of knowledge and learning. Hofer and Pintrich (1997), define epistemological beliefs as individuals' conceptions "about the nature of knowledge and the nature or process of knowing" (p. 117). In learning science, beliefs that students have about the nature of science and science learning, have been shown to influence achievement (Driver *et al* 1994; Jehng, Johnson and Anderson, 1993; Schommer, 1990; Kember and Gow, 1989). The research question, in this connection, is: *What epistemological beliefs about science and science learning do the students have?*

1.4.4 Learning science after class hours

In the course of their schooling students develop learning skills and strategies that they used in executing learning tasks. Learning skills act as academic enablers. They are tools for enabling students to acquire knowledge and enhance their mental competence (Gettinger and Seibert, 2002). When learning skills are integrated and used by students "with a purpose in view" they become learning strategies (Nisbet and Shucksmith, 1986, p. 6). As Lawson (1994) notes, learning cannot take place if the prerequisite learning skills are not available in the learner. Examples of learning skills are reading, making own notes, working out a mnemonic, elaborating, problem solving, drawing diagram encountered in science lessons and working out exercises. Without these skills, learning would be difficult to achieve. It is hence important to determine whether the participating students in this study had and used appropriate skills or strategies to enable them to succeed in learning physical science. The research question in connection with learning skills and strategies is: *"What learning skills do students use when learning science after class hours?*

1.4.5 Metacognitive and self-regulatory skills

Apart from learning tactics and strategies, success in science learning is further conditioned by availability of control level learning skills and determination to succeed. Metacognitive skills have to do with a particular student's awareness and controll of his or her learning and the development of personal learning styles (Watts, 1991). Koch (2001, p. 760) defines metacognition as "a construct that provides insights into awareness and executive control of knowledge construction". Similarly Llewellyn (2005) defines metacognition as awareness and regulation of one's learning processes. Case and Gunstone (2002) suggest that development in students' conceptions of learning, improvements in the organisation of students' learning and ability to assess own learning are aspects of metacognitive development. The concept of metacognition is too limiting because it excludes motivation (Pintrich and DeGroot, 1990) and behaviour (Zimmerman, 1989). There was hence a need for a more encompassing construct to describe learning at school level. Self-regulated learning is the more accommodating construct and is described next.

Awareness of ones learning skills or strategies and their efficacy leads to self-regulation of ones learning. As McCombs (1988) notes, self-efficacy judgements and attributions of success or failure to personal control were initially considered to be the main components of motivated learning. Other components of motivated learning according to McCombs (1988) included alertness, selectivity, connecting, planning and monitoring. Zimmernann (1989) maintains, in this connection, that a student can be described as self-regulated in as far as they are "metacognitively, motivationally, and behaviourally active participants in their own learning". Similarly, Ertmer, Newby and MacDougall (1996) define self-regulation as ability and motivation to implement, monitor, and evaluate various learning strategies for purposes of improving one's learning. Azevendo, Guthrie and Seibert (2004) concur with Ertmer *et al*. (1996) when they propose four phases of self-regulated learning namely: planning and goal setting; monitoring processes of the self, learning task and context; control and regulation of aspects of self, task and context; and, reactions and reflections on the self, learning task and learning context. Metacognition is in the formulations of these authors a subset of the set of the set of self-regulated learning. The self-regulated learner uses metacognitive and other self regulatory skills to improve his or her learning. The research question concerning metacognitive awareness and use of self-regulatory skills seeks to determine the extent to which the students can be described as self-regulated learners. The question is: *What self-regulatory skills, if any, do the students use when learning physical science?*

1.4.6 Attribution of success or failure

According to Mayer (2003) students work hard when they believe that their efforts in learning will lead to achievement of their objectives. It is hence important to find out to what students ascribe their success or failure in learning. Tendency to attribute success or failure to other factors other than the student's efforts is generally associated with lukewarm approaches to learning and may be indicative of debilitative rather than facilitative orientation to learning tasks (Kerlin, 1992). The research question in this connection is: *To what do the students attribute their failure in physical science?*

1.5 Rationale, purpose and importance of the study

This study builds on the rationale that what happens at preceding stages in education affects subsequent stages. The implication here is that where the general quality of primary school graduates is low, the quality of secondary education is likely to be low. Selection of students on merit, however rigorous, cannot make up for the poor quality of learners at secondary school. This point was emphasized by the Phillips Commission (1962). This study advances this thesis of Phillips Commission (1962) that where the quality of primary school graduates is poor the quality of learning in secondary school is likely to be low. The study attempted to demonstrate the thesis of Phillips Commission through showing that the students who were selected on merit hold, nevertheless, dysfunctional personal epistemologies of science and science learning, and used inappropriate study skills when learning physical science.

This study is different from previous studies in three ways. Unlike previous studies, this study incorporated a historical dimension and adopted a social and individual constructivist perspective. Knowledge of the history of the problem facilitated fuller understanding of the ramifications of the problem. The adoption of a social and individual constructivist perspective enabled the researcher to examine the problem from both the national and the individual perspective, thereby combining qualitative and quantitative methods. The second difference is that the study sought to investigate students' constructs of meta level concepts rather than science content level. Van Rossum and Schenk (1984) refer to the meta level perspective as the second order perspective. These authors regret that many studies about human learning are done at the first level which is a level of description of reality. They recommend doing such studies at the second level perspective where the focus is on the learning characteristics of the learners. The study sought to characterise the students as learners. It sought to find out how the learners function as they carry out a learning task and to determine what learning skills and strategies they use when learning physical science.

Epistemological beliefs have become an important dimension in the study of learning. This study investigated students' epistemological beliefs. If personal epistemologies about science and science learning can facilitate or impede learning of science as the literature suggests, it seemed necessary to investigate the problem of poor performance in physical science from the perspective of these beliefs.

The importance of the study lies in the information it has generated. The information gained has extended our understanding of the performance of students in secondary schools. At policy level in education in Malawi, the study has underlined the importance of meta level factors in school learning. Such factors as students' conceptions of learning are rarely addressed in existing curricula. The study will help to bring meta level factors in students' learning to the fore in teaching and learning.

Since learning skills and meta-cognitive skill can be explicitly taught (Donovan and Bransford, 2005; Fairbrother, 2000), teachers of science in Malawi will benefit from the study through use of learning and metacognitive skills to improve performance of students in national examinations. The information gained in this study will thus be used in addressing the problem of poor performance in science anew. The study has also helped to sensitised teachers and educational administrators to the long history of the problem of poor performance of Malawian students in science and the need for a viable solution to it.

1.6 Theoretical and conceptual framework

This section presents the theoretical and conceptual framework of the study. The overarching theoretical framework for this study is constructivism. The central concepts of the theoretical framework of this study are individual and social constructivism, theories of learning, self-regulated learning and disadvantaged students. These concepts are explained briefly in this section but are explained in detail in chapter 4. Other concepts that constitute the theoretical framework of the study are: situated learning, metacognition, epistemological beliefs and self-efficacy. These concepts are also briefly explained below.

Constructivism maintains that knowledge is constructed in the mind of the student (Bodner, 2004). The central tenet of constructivism is the idea that "conceptions held by each individual guide understanding" (Duit and Tregust, 1998, p. 8). Constructivism has been chosen as the overarching theoretical framework for two reasons. First, there is "widespread acceptance" of constructivism as a theory of learning and teaching (Ogunniyi, 2002, p. II-70). In addition empirical studies such as Wu and Tsai (2005) and Uzuntiryaki and Geban (2004) have have demostrated the superiority of constructivist orientated instruction over traditional teaching in terms of students' achievements. Constructivism as Tobin (2002, p. 32) states is "the current paradigm in science education". Second, the constructivist perspective offers ways of making sense of commonly observed things in classrooms such as students' persistent mistakes (Trumbull, 1990). Identifying sources of persistent errors has become more important than merely giving students correct answers. This study seeks to identify matacognitive and epistemological factors, of which the students may be unconscious, but which, nevertheless, affect their learning of physical science.

Constructivism is both an epistemological view of knowledge and a theory of learning. The two aspects of constructivism have bearings in the conceptualisation of this study. Constructivism as a theory of learning and as a theory of knowledge is discussed briefly in the following paragraphs.

1.6.1 Constructivism as a theory of learning

Constructivism, as a theory of learning, stipulates that knowledge is a human construction. Jenkins (2001, p. 55) maintains that a central characteristic of constructivism is idea that "the development of understanding requires active engagement on the part of the learner". To Jenkin's active engagement must be added Ausubel's (1978) appropriate prior knowledge in the learner if learning is to take place. Thus the main features of constructivism are active engagement of the learner and emphasis on the role of prior knowledge in human learning.

Constructivism is an over generalisation of the constructing or making metaphor of learning. Earlier metaphors of learning are seeing, finding, discovering and responding to stimuli. Cultivating agency is a more recent metaphor of learning. According to the constructivist view of learning, learners construct knowledge by interpreting experience in terms of previous knowledge. As Tsai (2002) asserts, peoples' subsequent actions and thoughts are constructed from their earlier ideas. Cobern cited in Tobin (2002) draws an analogy between the constructivist approach to learning and a construction site. Just as new structures are built on existing foundations at the construction site, new learning is constructed on the foundation of prior learning and experiences. In the constructivist perspective learning takes place when students use their prior learning to "interpret and make sense of their surroundings" (Tobin, 2002, p. 43).

As they interact with their teachers, peers, and instructional materials, students in primary and junior secondary school construct knowledge. The knowledge that students construct falls into two categories: knowledge about individual objects of inquiry of science lessons and knowledge about the science learning enterprise itself. Knowledge about the learning enterprise includes metacognition. Metacognition, as indicated previously, is knowledge, awareness and control of one's own learning (Gunstone, 1994). The main objects of inquiry of this study: self-efficacy, self-regulated learning, epistemological beliefs, and study skills and strategies are aspects of constructs or habits that students build or acquire from their experiences in school.

Inquiring into meta-cognitive knowledge means inquiring into students previous experiences in the course of which the knowledge was constructed. This study thus seeks to co-construct metacognitive knowledge so as to gain insights into the prior circumstances in which students' construction of knowledge occurred.

1.6.2 Constructivism as a theory of knowledge

As a theory of knowledge constructivism is concerned with the nature of knowledge and what it means to know (Schwandt, 1994). According to von Glaserfeld (1991), knowledge in traditional epistemology is said to be true if it is considered to exist, prior to and independent of the knower's experience of it. Constructivism in its radical form rejects the idea that the validity of knowledge claims lies in the correspondence between the knowledge claim and an independently existing world. Constructivists maintain that the world can only be understood, from individually unique perspectives that are constructed through experimental activity in a social-physical world (Derry, 1992).

A knowledge claim in the constructivist paradigm is valid if it works to achieve a goal. The implication here is that individual's viewpoints should be assessed on the criterion of achieving a stated goal. The knowledge produced in the course of this study is not a reflection of some reality that exists, independent of the author. It is a model of some hypothetical reality that is consistent with the data collected. The validity of knowledge claims made in the study are to be judged by their usefulness in promoting understanding of the poor performance in science problem among scholars in science education and by the self-consistency of the findings of the study in relation to findings of other studies.

1.7 Author's pre-research theoretical starting point

In accordance with requirements of reflexivity in qualitative research (Vos, 2002; Cohen *et al.*, 2000) I state my pre-research theoretical starting perspective.

Reflexivity according to Horsburgh (2003) is active acknowledgement on the part of the researcher that the self impacts on the process of constructing knowledge. Hammerssley and Atkinson (1983), state in this connection, that a researcher "cannot escape the social world in order to study it" (p. 15). Von Glaserfeld makes a similar observation when he talks about the "impossibility of attaining an uncorrupted image of reality as such" (von Glaserfeld, 2004, p. 381). In similar vein Johnson-Laird quoted in Watts (1991) maintains that human beings do not apprehend the world directly because they possess only an internal representation of it. According to Johnson-Laird perception is the construction of a model of an aspect of the perceived world. Such a constructed representation cannot be compared directly with the phenomenon from which it has been derived. Failure of researchers to escape their social world means that the knowledge they construct will be tainted by their pre-research perspectives hence the need to declare them. The theoretical perspective that is likely to influence my outlook is post colonial experience in Malawi.

1.7.1 Post-colonial experience

Malawi was colonized at the end of the 19th Century. Colonial rule ended in 1964, seventy-three years after its inception. Like other previously colonized people, the people of Malawi have to escape their past. Cohen (1976) explains succinctly the burden of escaping one's past:

> To Freud, neurosis is the failure to escape the past, the burden of one's history. What is displaced, returns, distorted and, is eternally re-enacted. The psychotherapist's task is to help the patient reconstruct the past. In this respect the historian's goal resembles that of a therapist-to liberate us from the burden of the past by helping us to understand it (p. 329).

During the colonial period, performance of Malawian students in national examinations was understood in terms of the colonial masters' perceptions of the problem. Poor performance of African students in science subjects was expected. Differences in performance of European and African students were explained in terms of the intellectual superiority of European students. In his comment to Professor Julian Huxley's proposal for introducing the teaching of Biology in schools in Nyasaland, Lacey (1932), for instance, argued that less than 20% of African children in schools "ever reach the intellectual level of a white child of twelve years of age" (p. 2). Similarly, Swelsen (1932) cautioned against comparing Africans with whites because in his view there was a big rift between the standards of attainment of African and European children. These experiences were not limited to Malawi. In the following paragraph similar experiences drawn from Japan and India are presented.

Writing from the perspective of Japan, Inkster (1990) reports that Japanese initial lack of success in learning science was explained in terms of what was called a "Japanese mindset" (p. 397) which was considered to be inferior to the Western mindset. Similarly, initial failure of Indians in learning science was explained in terms of habits and prejudices of Indians and their attachment to ancient customs (Sangwan, 1988). It seems that the colonial masters tended to look down upon the intellectual qualities of colonized people. Surprisingly, the colonized people seem to accept for some time their colonial masters' assessment of their performance in science until the need to re-conceptualize their history arises. It seems that re-conceptualization of the science teaching history of Malawi has not been accomplished and this study is partly an effort in that direction.

1.8 Synopsis of the thesis

This thesis has 8 chapters. Chapters 1, 2, 3, 4 and 5 are of a general nature while chapters 6 and 7 are of specific relevance to the problem that was investigated in the study. The history of the problem under investigation is presented in chapter 2. In chapter 3, I describe the the physical and educational context in which the study was done. The research design and methodology of the study are discussed in chapter 6. The review of the literature related to the problem is the subject of the sixth chapter.

Results of the study are presented and discussed in the 7th chapter. Conclusions and recommendations of the study constitute the substance of the 8th chapter.

CHAPTER TWO

Digging up the story of the problem

2.1 Introduction

This study was done in Malawi, a small country in Eastern Southern Africa. The development of science education in Malawi has been influenced by both continental and country factors. This chapter discusses the development of science education in Africa before presenting the story of science education in Malawi. The problem that is investigated in this study, as previously indicated, has a long history, it seems reasonable, to begin by informing readers about the history of the problem. Layder (1993) states that every research project or topic has a history and the researcher must be aware of that history.

2.2 Development of science education in Africa during the colonial period

A study of the history science teaching in Anglophone Africa suggests that science education in that part of the continent has been the result of the conflict between adherents of two schools of educational policy: the adaptation school and the imitation school. The adaptation school maintains that the purpose of education is to fit the individual to his or her environment (Lugard, 1965; Jones, 1924; Hetherington, 1978). The conclusions that emerged from the missionary conferences held at High Leigh in 1923 and from the other Conference at Le Zoute in Belgium in 1926 indicate a shift in missionary policy of education in Africa from the imitation school towards the adaptation school (Hetherington, 1978). According to Hetherington "education was not to be the means of introducing Africans to world civilization but the means of achieving stable, even compliant, populations in colonial Africa" (Hetherington, 1978, p. 117). The proceedings of the Conference on Christian Education in Africa held at High Leigh from 8-13th September 1924 support Hetherington's (1978) position on objectives of education in African colonies:

> The most vital factor in the determination of educational objectives is a consciousness of the needs of both the individual and the community. Such a consciousness, if allowed to govern action, will inevitably result in the adaptation of all education activities to the life of the individual and the community (Proceedings of Christian Education Conference in Africa, High Leigh, 1924, p.4).

In similar vein to the excerpt above, Sir Frederick Lugard argued at the Le Zoute Conference in 1926 that it was more important to educate the mass of the people so as to improve the general standard of life and the conduct of the community than to "endeavour to make imitation Europeans of a small section by a literary education crowned by a University degree" (Lugard quoted in Hetherington, 1978, p. 117). Hetherington (1978) explains that the conclusions of these conferences reflected fear that a "broad Western education would promote subversive ideas" (p. 117). Jegede and Okebukola concur with Hetherington when they state that missionaries and colonialists did not approve the teaching of science because they feared "the power it would confer on the African natives" (quoted in Jegede, 1997, p. 6). Barinaga cited in Baker (1998) lends support to Jegede's position about colonial administrators' unwillingness to teach science to subjects in their colonies when she maintains that indigenous citizens of the colonies were not generally provided opportunities to learn science. Not all missionaries and colonial administrators, however, agreed with the adaptation school of educational policy. In the following paragraph, the position of the imitation school of educational policy is presented.

The imitation school considered the role of missionaries in Africa to be trustees of the natives. As trustees it was their duty to prepare Africans for eventual independence

(Hetherington, 1978). In her book about British paternalism and Africa, Hetherington (1978) describes successful education in the imitation school. She writes:

> In the past missionaries had counted themselves successful if their work in the field of education had produced black Englishmen, Africans who seemed to have assimilated Western culture. But these mission educated Africans were an anathema to many administrators and others. They were 'cheeky' and demanded social equality and political rights (Hetherington, 1978, p. 111).

In the excerpt above Hetherington portrays a picture of a mission educated African in the imitation mode. She also refers to the seemingly unruly behaviour of Africans educated in this manner and to their demands for equality with Europeans. Elsewhere in her book, she further states that the colonial administrators saw the need to slow down the rate of progress to independence of African colonies. What Hetherington does not tell us is the conviction that some missionaries cherished about the need to produce African leaders through education. Robert Laws of Malawi was adamant about using education to produce African leaders (Laws, 1934). According to Laws Africans with appropriate ability and disposition had to be identified and educated to enable them to take up leadership roles in their society. So important was the need to train African leaders that when Mr. Cox the then Colonial Office Education Adviser visited Nyasaland in 1943 to find out what was withholding her progress in education, he concluded that Nyasaland had to "catch up in the training of leaders of all types" (Cox, 1943, p. 13). Mr. Cox elaborated that Nyasaland needed to consolidate primary education, extend secondary and vocational education and provide bursaries for further professional education. Thus the need to educate leaders of Africans that Laws felt and attempted to address at the beginning of the 20th Century changed into the need to train Africans who would carry out duties as assistant officers in various offices in the aftermath of the First World War. It is to this need for assistant officers in the colonial administration that Anglophone Africa owes the introduction of science teaching in its schools. The factors and mechanics of the introduction of science teaching are presented next.

2.2.1 Factors that contributed to the introduction of science teaching in Africa.

Four factors acted together to bring about science teaching in Anglophone Africa. The factors were the general shortage of European personnel that British colonies experienced after the First World War, the rise of Biology as a school subject, Professor Julian Huxley's report on Biology and its place in native education in East Africa, and the education provided to Africans by missionaries. The first three factors are briefly discussed in this section while the fourth factor-education provided to Africans by missionaries is discussed in the next section.

Shortage personnel during and after the First World War

During the First World War British colonies in Africa experienced a need to recruit and train Africans who would to take up jobs that were previously done by expatriate staff (Onabamiro, 1964). Smith (1932) maintains that the need for trained African personnel was most acutely felt in those colonies that had a small proportion of resident Europeans. In such colonies Africans had to be trained to perform duties of assistant officers in various professions. The Shortage of European personnel worsened at the end of the First World War. So bad was the shortage of personnel in the early 1930s that a decision to train Africans to the level of assistant officer in various professions was made in Whitehall (Onabamiro, 1964). To implement the decision three post-secondary educational institutions were established. The established institutions were Yaba Higher College in Nigeria, Achimota College in Ghana, and Makerere College in Uganda. Each institution admitted students from surrounding colonies as well as nationals. Some Malawians were trained at Makerere following this arrangement.

Unlike most university colleges in which establishment of faculties of arts precede establishment of faculties of science and applied sciences, the three institutions named previously opened with faculties of arts, science and applied science. For instance, Yaba College opened in 1934 with faculties of medicine, agriculture, engineering, surveying and teacher training (Fafunwa, 1971). Similarly by 1949

Makerere Junior College had faculties of arts, sciences, medicine, agriculture and veterinary science (Ruth Sloan and Associates, 1962). Fafunwa (1971) suggests that higher education in Africa was instituted to train officers and assistant officers in various professions. Fafunwa's suggestion agrees with the Currie Report that emphasised the need for giving priority to the establishment of faculties of medicine, engineering, agriculture, veterinary sciences, commerce, and applied sciences when establishing university colleges in Africa (quoted in Berry, 1970, p. 3). The science biased university colleges created the need for preparing students in secondary schools to the standard for admission to these colleges. This need to prepare students for admission to the university colleges in turn gave rise to the teaching of sciences in secondary schools in British Colonies in Africa. Science in Africa is a means of preparing students for science related job it rarely affects day to day living of the majority of Africans (Dzama, 2003).

Rise of biology as a school subject

In the 1930s biology gained an established place in the secondary school curriculum in England (Jenkins, 1979). As Jenkins observes, being first in the field, physics and chemistry were able "to consolidate their position in schools by the development of appropriate teaching techniques" (Jenkins, 1979, p. 116). Biology was included in school curricula because of its contribution to understanding of human life and laws of health. There were many reasons for teaching biology in Tropical Countries as Saunders reports:

> To the question 'why teach biology?' there are numerous answers: to improve the methods of agriculture and animal husbandry; to raise standards of hygiene, both public and private; and to reduce sickness and disease; to give pupils understanding of their environment and to increase their ability to control it; to enable them to appreciate scientific methods, especially the use of control experiments; to encourage their powers of observation; to instruct them in orderly management of knowledge and to draw attention to the beauty of many of nature's products (Saunders, 1958 p. 73)

According to the excerpt above many advantages for teaching biology in schools were suggested. It was only natural that the Advisory Committee on Education in British Tropical Africa in London became interested in this matter. The Advisory Committee began to discuss the introduction of Biology to schools in the colonies on the initiative of the British Social Hygiene Council (Sivonen, 1995). In its memorandum to the Imperial Education Conference, the British Social Hygiene Council stressed the need for teaching biology in the colonies as a means of raising standards of health and sexual instruction. The Advisory Committee hired the services of the well-known biologist, Professor Julian Huxley to study and advise the Colonial Office on the feasibility, timeliness and necessity of introducing the teaching of biology in schools in the colonies in East Africa. Dr. K. W. Spencer and Mr. S. A. Hammond assisted Professor Huxley especially with their practical teaching experience in schools in England and in Africa (Huxley, 1931). It is in the colonial administrators' reactions to Huxley's report that one finds clear evidence of their reluctance to introduce the teaching of science in schools. A summary of Huxley's report is presented next, but the reactions of Malawi's missionaries and colonial administrators to the report are presented later.

Summary of Huxley's report

Huxley's report endorsed and extended the report of the Phelps-Stokes Commission that was issued in 1924. Snelson (1990) says that the task of the Phelps-Stokes Commission was three-fold: to investigate the educational needs of the people of the countries visited; to determine the extent to which the needs were being met; and to formulate plans for meeting educational needs of Africans. The Commission condemned the literary education that was provided by some missionaries like those of Livingstonia in Northern Malawi (Jones, 1924). It stated that education must be adapted to the conditions of life and needs of society. In case of Africans, the Commission argued that education must be preparation for life in the village. The Commission hence recommended that education in African countries should concentrate on health and hygiene, agricultural development and the teaching of industrial skills. Development of character through religious training was also recommended. Although the Commissioners denied that their aims of education were calculated to keeping Africans from competing with Europeans in leadership positions in the colonies, there is evidence that the Commission had a political motive. Sivonen (1995) for instance, maintains that political factors lay behind the journeys the Phelps-Commissions. Furthermore, Berman (1982) shows that Jones the leader of the Commissions espoused in the reports the philosophy of education that sought to train Africans as "semiskilled, semiliterate and co-operative member of a burgeoning work or agricultural force" (p. 184). Huxley's report indicates awareness of the political agenda embedded in the Phelps-Stokes Commission reports.

Huxley claims that his report builds on the general ideas and recommendations of the Phelps-Stokes Commission and extends them a stage further (Huxley, 1931). He felt that education of Africans in the early colonial period was merely a means of converting Africans into "more efficient servants of the white man's economic system" (Huxley, 1931, p. 10). Like other education experts he points out that the attempt to provide Africans with European education resulted in the production of Africans with excessive attachment to book learning, great desire for clerical employment and "contempt for all forms of manual work" (Huxley, 1931, p. 8). Huxley felt that these tendencies among educated Africans should be eliminated.

Turning to his main task, Huxley found that inclusion of biology in the curriculum in African schools was both desirable and applicable. Among the advantages of including biology in the curriculum of African countries Huxley mentions the need to provide system and coherence to the teaching of agriculture and health. Huxley felt arrangement of curricula in these subjects was scrappy and unsystematic where biology was not included in the curriculum. In Huxley’s view, health and agriculture stand in organic relationship to biology. Thus biology provides a unifying core to health and agriculture. Huxley further argued that beginning from the pupils' environment education must proceed to beyond that environment. It should grow out of the village to the local town, to other countries and to the world. From the immediate present education should in Huxley's thinking, move towards the "future, out of the actual towards the possible and the ideal" (Huxley, 1931, p. 7). Besides biology and agriculture, Huxley recommended teaching of chemistry, physics, nature study and general science (Huxley, 1931, p. 36). These recommendations were based on the need to prepare Africans for training as assistant officers. Huxley (1931) says Government Officers indicated to him that they needed "a large number of specially-trained native assistants" (p. 10). It was the need for technically trained native assistants that provided the impetus for teaching of science subjects in schools in countries in Eastern and Southern Africa. In spite of the contrary views of some colonial administrators in the then Nyasaland, the British Government went ahead to establish institutions of higher learning in Africa that in turn promoted science teaching.

2.3 Introduction of science education in Malawi

The colonial period began in 1891 when Nyasaland became a Crown Colony and ended in 1964 when it attained independence. The key players in science education during this period were the colonial administrators, the missionaries and the Africans themselves. It is important to know that there was diversity of opinion within these groups. Not all missionaries for instance opposed the teaching of science in schools. Similarly not all colonial administrators opposed the teaching of science in African schools.

2.3.1 Circumstances that led to the introduction of science in schools in Malawi

An examination of archives, records, books and reports concerning education in the early 1930s, indicates four factors that account for the introduction of science in schools in Malawi. These factors are: education provided by missionaries, criticism of education provided by missionaries and colonial administrators in Africa; shortage of European personnel in African colonies after the First World War; and, the rise of biology as a school subject. Two of these factors are discussed more fully in the following paragraphs. Since shortage of European personnel and the rise of biology as a school subject have already been discussed, only the first two factors are discussed below.

Education provided by missionaries to Africans

Sixteen years of missionary work preceeded establishment of colonial rule in present day Malawi. Colonial rule was established in 1891. The first permanent Scottish mission arrived in the country in 1875. Another Scottish mission arrived in 1876. These Scottish missions were followed by missions of the Anglican Church in 1885, the Dutch Reformed Church in 1889, the Zambezi Industrial Mission in 1892, the South African General Mission in 1900 and the Catholic Church in 1901 (Pachai, 1977; Pretorius, 1972). Some missions used schools as auxiliaries to their churches. To these missions the school was a "way of getting children into catechism" (Guilleme cited in Linden and Linden, 1974, p. 144). Other missions such as the DRCM considered schools to be an essential part of evangelisation and insisted that membership of their church should be restricted as much as possible to Africans who can read and write (Pauw, 1980; Retief, 1958). With passage of time most church missions began to appreciate the importance of the school in their work. Hinsley the Apostolic-Visitor to the Catholic Church in Malawi in 1928 told Catholic Missionaries that the Pope had advised him to tell them that wherever they had to decide between building a church or a school, "the school should have first preference" (Hinsley quoted in Linden and Linden, 1974, p. 157). As Ajayi (1965), writing from the West African perspective asserts, missionaries saw in schools "the nursery of the infant church and the principal hope for success of their work" (p.134). Similarly, Steytler (1939) maintains that missionaries have from the beginning of their activities in Africa believed in "education as a powerful instrument for Christianization and civilization" (p. xi). Steytler (1939) states further that education was expected to give Africans a new content to their lives. This implies that the missionaries expected Africans to develop a new culture. The critical question about missionaries in the 1930s, in as far as science education is concerned, is not about their willingness or unwillingness to provide education, it is about the kinds of education that they felt necessary to provide.

Policies of church missions concerning education in Africa can be broadly classified as indicated previously, into two categories, imitation and adaptation. Missions that followed imitation policy sought to offer Africans the same education as was being offered to children in schools in Europe. Proponents of the adaptation policy attempted to adapt Western education to the cultural heritage, environment and customs of Africans. These policies are further discussed and illustrated in the following paragraphs.

Livingstonia Mission of the Free Church of Scotland in Malawi followed the imitation policy. The Mission sought to find and develop young Africans' talent and skills in the vicinity of their mission stations. This mission transplanted European syllabuses from Scotland to Malawi. The curriculum of the imitation missions was meant to service the needs of European settlers in Southern Malawi and in neighbouring countries rather than needs of Africans themselves (McCracken, 1977a).

One of the first missionaries of Livingstonia Mission, Robert Laws, was for about 50 years at the helm of the mission in Northern Malawi. Laws explained the purpose of education in missionary schools. Education for Africans, according to Laws, means absorption of new knowledge, new experiences and new lines of conduct (Laws, 1934). In his view, Africans had to change not only from "heathenism to Christianity but also from barbarism to civilisation" (Laws, 1934, p. 96). Laws further asserted that Africans were not ready to assume leadership roles when they became Christians. To become leaders of their people Africans had to be educated. To that end Laws established the Overtoun Institution. The purpose of the Overtourn Institution was to instruct Africans in the arts and skills of civilised life. The curriculum followed at the Institution was of a literary nature. In defending the literary nature of the curriculum Laws maintained that "to discard or even to lessen the literary training would be to block the way for the advancement of leaders and means the reduction of natives to a class of helots" (McCracken, 1994, p. 6). The training of leaders appears from the quotation above to have been the main function of the Overtourn Institution. As indicated earlier in this chapter, the training of leaders has been a recurring theme in colonial education literature and provided the basis for introduction of science education in British colonies in Africa.

The DRCM followed the adaptation policy in its provision of education to Africans. Unlike Livingstonia mission that concentrated its educational efforts on the "elect few in order to give them the highest and best education" (Pauw, 1980, p. 153), the DRCM emphasised providing reading and writing skills to as many people as possible (Retief, 1958). The central aim of the DRC mission was to establish in the country a "Bible-loving, industrious and prosperous peasantry" (Pretorius, 1957, p. 11). By insisting on the teaching of agriculture, hygiene, simple village industries and better use of natural resources, the mission attempted to "fit the men and women to become home workers" (McCracken,1977b, p. 178). The DRC resisted the teaching of English in its schools and opposed the establishment of secondary education in the country (Retief, 1958). Mufuka (1977), states that the DRCM did not offer education beyond Standard 3, before 1927 (p. 83).

Some of the missionaries encouraged teaching of nature study, hygiene and agriculture in their schools. The Mission Council of the DRCM for instance, resolved in 1920 to give thorough instruction in hygiene and nature study in order to "fight the power of superstition more effectively" (quoted by Retief, 1958, p. 92). As previously indicated, some of the missionaries and colonial administrators were opposed to teaching science to Africans. The teaching of biology, physics and chemistry in secondary schools in the country was, however, introduced through actions and advice of the Colonial Office in London. The education provided by missionaries served as a base, the improvement of which brought about the teaching of science subjects in schools in the country.

Criticism of education provided by missionaries and colonial officers

The education that missionaries provided Africans was criticised by colonial administrators and African nationalists. The criticism levelled against missionary education is important today because some aspects of colonial education have outlived the period of colonial masters and missionaries in African history. Mou'mouni (1968) maintains that colonial education continues to influence developments in contemporary Africa. The problem that is being investigated in this study, the problem of poor performance in science among students in Malawi is an example of a relic of colonial experience that has outlived the colonial period. Criticism of education by colonial administrators is presented first and is followed by that of Africans in the following paragraphs.

Colonial administrators' criticism of missionary education

To appreciate Europeans' perceptions of education that missionaries offered Africans, one needs to understand prevailing ideas in Europe about education of the labouring and governing classes. Africans were considered to be a species of the labouring classes. According to Mr. Giddy, President of the Royal Society in England in the 1870s, giving education to the labouring classes is likely to make them amoral, unhappy, fractious and refractory, and may render them insolent to their superiors (Giddy quoted by Dougall, 1939). Thus because of the reasons stated by Giddy, the governing classes in Europe were opposed to providing education to the labouring classes. In his analysis of the problem of attitudes of Europeans to African education, Dougall (1939) draws a parallel between attitudes of the governing classes to education of the poor in England in the 18th Century and attitudes of many white people to education of Africans during the colonial period. Hobley (1923) concurs with Dougall (1939) when he writes about a school of thought that maintained that people are best "left in their primitive ignorance" (p. 290). Thus in view of their backgrounds most colonial administrators could not be expected to support education of Africans. Colonial administrators' attitudes to education of Africans in Malawi, however, were further influenced by three factors. The first factor was the general belief among Europeans about the Africans' limited intellectual capacity (Sheffield, 1973; Buell, 1965; Moumouni, 1968). The second factor was the need for European estate owners to use African labour in creating wealth for themselves. The third factor is the rebellious character of educated Africans. The most significant rebellion of missionary-trained Africans was the Chilembwe Rising of 1915. This Rising signified to the colonial administrators the apparent failure of missionary absolutism. Missionary absolutism means efforts made by missionaries to produce Africans with European values and culture (Hetherington, 1978). In the Chilembwe Rising, a group of Africans led by John Chilembwe rebelled against the colonial government. They killed three Europeans in the course of the rebellion. The rebellion was quelled and about 20 Africans including John Chilembwe its leader and the ringleaders of the Rising lost their lives (Leys, 1926, p. 329). The rebellion impressed it upon the minds of colonial administrators that education of Africans can be a danger to Europeans and Africans. The first Director of Education in Nyasaland minced no words about the dangerous nature of African education when in his letter to the Colonial Office in London, he wrote, "leaning unless carefully handled can become a very dangerous thing" (Gaunt, 1927, p. 1-3). In the 1920s and 1930s debates, not only on what kind of education should be provided to Africans, but also on why and whether Africans should be educated at all became common (Azikiwe, 1931; Dougall, 1939; Pearce, 1988). Most colonial administrators and European farmers and industrialists in Malawi were opposed to providing education to Africans (Shepperson and Price, 1987). One of the prominent members of the Nyasaland Legislative Council, A. L. Bruce made no secret of his feeling that Africans of Nyasaland had been "pampered by missionaries" who filled their heads with completely unrealistic ideas (Williams, 1978, p. 107). The District Commissioner for Karonga District made a similar remark in 1929. In that year the Penal Code that introduced punishment for sexual relations between black men and white women while saying nothing about similar contact between white men and black women, was promulgated. Africans protested against this Penal Code. In reaction to the protests, the District Commissioner for Karonga, talked about “Africans who had been miseducated at Livingstonia” (Williams, 1978, p. 123). Livingstonia was a leading centre of African education of the Free Church of Scotland. The District Commissioner implied that inappropriate education had been provided to the Africans who protested against unfair laws. In the same vein, an article in the Nyasaland Times of 14 March 1924 protesting against providing Africans with post-primary education called the African a "labourer”. It was the view of the colonialists that such education gave “the labourer an exaggerated idea of his position” (quoted in Linden and Linden, 1974, p. 152-153).

The attitudes of the colonial administrators sprang from their convictions about the structure of society. It was generally held among colonial administrators, farmers and industrialists in the 1920s and 1930s that people were borne to occupy specific positions in an imaginary social scale. People’s positions in the imaginary social scale were referred to as their stations in life. The positions of Africans in the imaginary social scale were naturally inferior to that of Europeans. Writing from the perspective of Mozambique that was similar to that of Malawi, Marshall (1993) observes that schooling was used to convince Africans and colonial administrators about the appropriateness of their stations in life. It seems that so long as education made Africans to be contented with their social positions in life, it was acceptable to the colonial administrators. The conclusion in the last sentence of the preceding paragraph is supported by an incident that took place in 1911. A newly appointed Priest in Charge of Mua Catholic Missionary Station in Central Malawi paid a courtesy call on the Governor of Nyasaland in 1911. During the call, the Priest was praised by the Governor because Africans educated in Catholic Schools, unlike those educated in schools of other missions, kept to their stations in life (Linden and Linden, 1974). In the view of the Governor, the Catholic Church was doing a good job in education because graduates from Catholic Schools caused the administration no problems.

Colonial administrators' opposition to literary education is evident in Poole's letter of 13th May 1895 addressed to his father. Poole was a medical doctor who worked in Malawi and was based in Zomba in the early 1890s. In a letter to his father, Poole wrote:

> It is an odd thing but I really think that the boys from the mission are the worst thieves. In fact the first advice you get here about boys is that "Whatever you do don't have boys from the missions." They are insolent and think of no end of themselves because they can read and sing hymns (Poole, 1895, folio 10).

In the same letter Poole indicated that missions did a great deal of "good work in teaching various trades" (Poole, 1895, folio 10). Christian Missions were taken by the colonial administrators to be doing good work when they concentrated on teaching various trades and refrained from teaching literary skills. Earlier, Sir Bartle Frere criticised missions in the neighbourhood of Zanzibar for providing Africans with a too bookish education (Frere cited in Oliver, 1965). Similarly in his book on the dual mandate in Tropical Africa, Lord Lugard criticises literary education in Africa. Lugard quotes approvingly a French writer to the effect that literary education only produces "hostility and ingratitude" among Africans (Lugard, 1922, p. 428). In Lugard's view Africans educated in mission schools were unreliable, lacking in integrity, self-control and discipline, and had no respect for authority of any kind (see Lugard, 1922, p. 428). So influential were the views of Lugard on native education that the Acting Governor of Nyasaland, His Excellency Hall quoted extensively from Lugard's book on the dual mandate in Tropical Africa when he addressed the Advisory Committee on Education on 7th June 1932. The Acting Governor's speech is worth quoting at length:

> I have no hesitation in saying that such education resulting in the creation of a semi-literate discontented class of natives unadapted to their environment is worse than none at all…I think perhaps we have cause to be thankful here in Nyasaland that Government assistance has been so belated.

> Lord Lugard I suggest crystallised the principles of an educational policy when he wrote “The primary function of education should in my judgement be to fit the ordinary individual to fill a useful part in his environment with happiness to himself and to ensure that the exceptional individual shall use his abilities for the advancement of the community and not to its detriment or to the subversion of constituted authority”.
>
> And the path towards this goal lies in my view through vocational training and technical education (Hall, 1932, p. 3).

In the first paragraph of the excerpt above, the Acting Governor is saying that it is a good thing that the government in Nyasaland took such a long time without assisting the missionaries in their educational work. A Department of Education was set up in Nyasaland in 1926, thirty-five years after the inception of colonial rule in 1891. According to the Acting Governor, Lugard’s dual mandate theory in colonial administration implied that Africans should be offered vocational training or technical education.

Although the Acting Governor in the excerpt above appears to be opposed to providing literary education, the Phelps-Stokes Commission reported in 1924 that mission-trained Africans were holding important positions in hospitals, offices and in the private sector in many colonies in Sub-Saharan Africa including Nyasaland. Clarke describes the attitude of colonial administrators to African education, as portrayed by the Acting Governor in quotation above, as one that was characterised by "double-mindedness" (Clarke, 1932, 162). According to Clarke (1932) segregation, trusteeship, indirect rule, mandate, conserving native institutions and Christianization characterised thinking of some Europeans as occasion demanded. The importance of educated Africans, as Macmillan (1934) stated was often "deliberately ignored" by Europeans (p. 137). Education of Africans was criticised by colonial administrators if it attempted to promote European values and culture among Africans.

Africans' criticism of education during the colonial period

Africans had their own criticism of education that was provided by Europeans during the colonial era. Africans pressed for better education through their native associations. The main criticism of European education in Malawi was that it was education for subservience in a European community. Levi Mumba the first African member of the Advisory Committee on Education put this criticism succinctly:

> The training which the African has received hitherto both in schools and through contact with white men either as semi-skilled or skilled workers has been aimed at fitting him as a worker for, instead of with the white man (Mumba quoted in Lamba, 1984, p. 13).

The subservient nature of European education that Mumba mentions in the excerpt above has been noted by many scholars (Huxley, 1931; Ward, 1959; Nyerere, 1967; Dikshit and Henery, 1974; Berman, 1975; Nkomo, 1981; Mungazi, 1982). Retief (1958) states that it was Article 22 of the Statutes of the League of Nations that provided for protection and uplifting of races in Africa. The implication here is that before the end of the First World War educating Africans for subservience was an accepted aim of African education among Europeans.

Mumba rightly noted that although Africans sensed a great need for education, the providers of education were slow in their response to the need (Nankwenya, 1977). Missionaries and colonial administrators were unable to open more schools and provide higher education (Van Velsen, 1966). Mumba was also concerned with the aims of African education. In his view neither educating Africans for service in European establishments nor educating them for service in tribal societies were appropriate aims of African education. Africans according to Mumba should be educated to stand on their feet. The North Nyasa Native Association and the Advisory Committee on Education provided the platforms from which Mumba presented to Europeans criticisms of education provided to Africans. The native associations drew the attention of the colonial government to such things as refusal of missionaries to provide places for higher education to children of suspended members of the church and arbitrary closing of schools (Van Velsen, 1966). The main criticism of education among Africans was slowness or unwillingness of the providers to meet the demand for it. Africans hence pressed for more and higher education.

As indicated previously, the Colonial Office in London contracted Professor Julian Huxley to study the situation in Anglophone Africa and advise it on the suitability of introducing the teaching of Biology in school in the colonies. In the following paragraphs reactions of colonial administrators and missionaries to Huxley's report in Malawi are presented.

Reactions to Huxley's report

Huxley's report was accepted in some church missions and rejected in others. An examination of the relevant archives indicates that the colonial administrators manipulated reactions from missionary societies to create the impression that all the missionary societies that were consulted about the matter disagreed with the proposal to begin teaching Biology. Reactions of the Catholic Church, the Dutch Reformed Church and the Technical Conferences of East African Dependencies, held at Dar es Salaam, March 1929 are presented seriatim.

Father Swelsen of Montfort Marist Mission agreed with three principles of Huxley's report; adaptation of the curriculum to the environment, introduction of biology in schools and the search for a unifying core of the curriculum. He, however, saw no need for qualified biologists (Swelsen, 1932, p. 1). Father Swelsen explains how the teaching of the physiological side of reproduction could be dealt with:

> Such teaching could be given to girls by a qualified nurse consequently there would be no need of expert biologists. Biology is then bound to be a helpful factor to eradicate a detrimental native customs (Swelsen, 1932, p. 1).

It is clear from the excerpt above that Father Swelsen was not interested in teaching biology as a science discipline as suggested by Huxley (1931). What the cleric was interested in was to use biology as a means of changing African customs that were considered bad by the Church. Father Swelsen expressed his opposition to teaching Africans biology very clearly in his reaction to Huxley's report. The cleric wrote:

> I plainly agree with another note of the same memorandum: we should not exclude from the curriculum any factor "which has proved helpful in the civilisation and culture of the white races". But in introducing "European" subjects in the African curriculum, we should avoid mere imitation and aim at proper adaptation. Mere imitation is in my candid opinion really harmful to the African and has proved to be the real cause of native rebellion throughout the continent. If the Negro fails to copy perfectly the whites, he starts to be envious, hence hatred and rebellion (Swelsen, 1932, p. 2).

Father Swelen's memorandum has been quoted at length because it was considered by the colonial administrators to be typical of the reactions of missionaries to Huxley's report and was sent to the Colonial Office in London as an attachment to the Acting Governors comments on the report. As indicted in the excerpt above, the opposition of missionaries to the teaching of biology as a science subject was motivated by fear that scientifically educated Africans may become frustrated and may rebel against the government and missions. The DRCM, however, did not share the fears expressed by Father Swelsen in the excerpt. The reaction of the DRCM is presented next.

In his reaction to Huxley's report, Steytler of the DRCM agreed fully with Huxley that "the development of Africa calls for the study of nature and that biology should be the framework and basic science of our education system" (Steytler, 1932, p. 1). In spite of his being in agreement with Huxley's report, Steytler, nevertheless, warned:

> It will of course be difficult to break away from what has become traditional and I expect that certain sections of the native community will view the new departure with distrust. On the other hand I am confident that when the people have realised the aims and benefits of the new scheme they will welcome it (Steytler, 1932, p. 1).

Contrary to Steytler's fears in the excerpt above, it was some missionaries and colonial administrators and not the native community who viewed the proposal with distrust. At the conclusion of his letter of reaction to Huxley's report, Steytler expressed confidence that most mission bodies would lend their "wholehearted co-operation in furthering the introduction of biology as the basic science in all our education" (Steytler, 1932, p. 1). Steytler's position on the introduction of biology as a science subject contrasts sharply with that of Father Swelsen. What makes these reactions significant in the introduction of science teaching in Malawi are events concerning them that took place at the Department of Education in Zomba that are described in the following paragraphs.

Commenting on Mr. Steytler's memorandum under minute 44 addressed to the Chief Secretary, Lacey, the then Director of Education wrote:

> Mr. Foster brought this to me in view of His Excellency's minute above. I must admit that I do not consider Mr. Steytler's memorandum to be nearly so valuable a contribution to the discussion as that of Father Swelsen, it is much too vague. I cannot candidly believe that the Dutch Reformed Church Mission would accept biology as a centre core of its system and I think Mr. Steytler really advocates the teaching of nature study and the choice of biology as a basic science in just the same way as Father Swelsen does though his wording is obscure.
>
> I suggest that Father Swelsen's memorandum should be forwarded with the despatch as representative of Mission opinion but that of Mr. Steytler's memorandum, which is hardly worth of him; need not be forwarded (Lacey, 1932, p. 8).

Minute 45 indicates that the Acting Governor's letter referred to as a despatch in the excerpt above was amended and Steytler's memorandum was removed. Furthermore the Acting Governor's despatch to the Colonial Office of 9th September, 1932 indicates that only one memorandum representative of mission opinion was sent to London. At the conclusion of his letter to the Colonial Office, Acting Governor, Hall wrote:

> As Mr. Lacey writes if room can be found for further specialisation it should be along anthropological rather than biological lines (Hall, 1932, p. 11).

The Acting Governor is in the excerpt above asking the Colonial Office to provide training to all education officers in the country in anthropology and not in biology as recommended by Huxley's report. The foregoing rejection of the proposal to start teaching biology was not an accidental occurrence but a reflection of a local colonial policy. At the Technical Conference on East African Dependencies at which Nyasaland was represented by Mr. Caldwell, the then Acting Director of Education, the biology issue was tabled and the following resolution was passed:

> The conference recognises the importance of the environmental aspect of education, and is of the opinion that no teaching can be effective which does not emphasise the environment of the child, whatever the particular subject.
>
> At the same time the conference feels that the introduction of biology as a specific science can hardly be considered a practical question at the moment. The conference considers that we must proceed with great caution in handling a subject that raises questions of tremendous import to missionaries and Christianised Africans. Moreover the standard of education and linguistic attainment is still so low that it is felt that, while the matter must not for a moment be lost sight of, the formation of a definite scheme must for the present be postponed.
>
> The conference recommends that selected education officers should be encouraged to take special courses of reasonable length in this subject…until qualified biology teachers are available in sufficient numbers (Technical Conference of the East African Dependencies, 1929, p. 12).

The resolution quoted above indicates unwillingness to introduce the teaching of biology in schools in British East African Dependencies on the pretence of the conflict between biology and Christianity. As indicated previously, some missionaries were more accommodating in their attitudes to the biology issue than the colonial administrators. Although conflict between biology and Christianity was the ostensible reason for refusing to start teaching biology in schools, the underlying reason for the refusal was, as previously indicated, the fear of scientifically educated Africans. It seems that the Colonial Office had no fear of scientifically educated Africans because in the 1930s it acted with haste to establish post secondary institutions such as Makerere College, with explicit orientation to providing Africans with science related undergraduate training. With the establishment of Makerere College in Uganda, colonial administrators opposition to the teaching of science in schools in the country took subtle forms as indicated in the following paragraphs.

Opposition to the teaching of science in schools

In 1937 a board called the Federated Missions Board was formed at a meeting of the Federated Missions at Nkhoma Mission in Central Malawi. The newly formed board was charged with the responsibility of planning for the establishment of the first secondary school in the country. The board met in the same year and recommended to the Nyasaland Government that the proposed secondary school should offer physics, chemistry, biology, health science and hygiene as some of the teaching subjects (Minutes of the Federated Board of Missions, 1937). The Nyasaland Government refused to approve the teaching of physics, chemistry and biology and asked the missionaries to teach general science instead. The refusal to offer physics, chemistry and biology was a new manifestation of the fear of the scientifically educated African. Failure of secondary school students from Nyasaland to get admitted at Makerere College caused the Colonial Office to suspect that something unusual was happening in Nyasaland. As previously indicated, Phillips Commission (1962) found that the practice of offering General Science at Ordinary Level, to students who proceeded to taking A Level examinations in physics, chemistry and biology, was a major cause of poor performance in science subjects at A Level. Opposition to the teaching science did not in Malawi end with attainment of independence as shown in the following section.

2.4 Science education in Africa in the post-independence period

Many African scholars seem to maintain that since attaining independence, African countries have made significant progress in providing science education to their citizens (Ogunniyi, 1986, 1996; Lewin, 1993; Jegede 1997; Yoloye, 1998). Progress in the teaching of science is, however, determined by such factors as the numbers of students who learn science (Lewin, 1993) or the resolutions and proceedings of international conferences concerning science that have been held in Africa (Ogunniyi, 1986, 1996). Some scholars have gone so far as to suggest that the conditions for teaching science are better in the post independence period than in the colonial period. Yoloye for instance, writes that in the 1950s "a few secondary schools taught physics, chemistry and biology but their facilities and equipment were inadequate" (Yoloye, 1998, p. 1). The implication of Yoloye's statement is that in the post-independence period physics, chemistry and biology are taught in many schools and that adequate facilities and equipment are available. Contrary to Yoloye's position, many scholars have pointed out the problem of lack of resources in African schools in the post-independence period. Black, Atwaru-Okello, Kiwanuka, Serwadda, Birabi, Malinga, Biumigishu and Rodd (1998) maintain that by the 1980s many science education projects in Africa "had not gone as far as hoped because of lack of resources" (p. 240). Similarly Ogunniyi, (1986, 1996), Rugumayo (1987) and Ajiyalemi (1992) refer to lack of resources for teaching science as a major problem in schools in Africa in the post independence period.

Elstgeest (1987), following the Brazilian educator, Paulo Freire, states that the main problem of science education in Africa is its failure to arouse "critical awareness" of ones situation in a way that would lead to action to change that situation for the better. To Elstgeest critical awareness is "ability to ask questions and to search for solutions" (Elstgeest, 1987, p. 92). Elstgeest writes:

> Absence of "critical awareness" absence of the ability to ask questions and to search for solutions, leads to fatalism and defeatism. Absence of skill to apply

> the scientific process stagnates, development. Ready made answers guarantee no effective action, no further development (Elstgeest, 1987, p. 92)

In the excerpt above Elstgeest suggests that absence of ability to ask questions and seek for solutions that take into account the prevailing circumstances is the main reason for the stagnation of science education in Africa. Ogunniyi (1986) concurs with Elstgeest (1987) when he writes:

> The embryonic development of science education will show in every cell of our development plans that in most African states today there are many undeveloped decision makers and advisers on science. All over the continent one sees all sorts of slip-shod and haphazard efforts at planning and implementation- crash programs for the training of science teachers and laboratory technicians, crash erection of classrooms and laboratories, crash implementation of a new policy on education, and so forth. Whether or not positive results will emerge from such activities is totally irrelevant to many a government. After all there are "intellectuals" who will prophesy an inevitable success, adequate planning or not.
>
> It is not that positive steps towards development of science and technology have not been taken; it is that steps taken have consistently lacked the scientific approach. Various hesitant and ambiguous attempts at planning and implementation of science education programs have been made, but these have practically always been improvised and rarely well implemented (Ogunniyi, 1986, p. 119).

In the quotation above Ogunniyi agrees with Elstgeest (1987) that the main problem with science education in Africa is the absence of scientific approach in the implementation of its programs. The indifference of governments to the possible consequences of the crash programs that Ogunniyi refers to, in the excerpt, points to lack of scientific approach in governments' dealings concerning science education.

In his paper on the development of science, technology and society curricula in Nigeria, Jegede (1988) mentions the quality of teaching and learning as one of the problems that have remained unchanged since the colonial period. Jegede (1988) states that although the aim of the official policy in Nigeria is to inculcate in children the spirit of inquiry and creative thinking, much that takes place in science classes amounts to presenting facts and principles of science. Peacock (1995) notes, in this connection, the dissonance between concepts of learning embedded in science curricula and concepts of learning held by students, teachers and parents in Africa. Peacock (1995) further states that in-country science projects in Africa tend to focus on the secondary rather than the primary schools. Ogunniyi (1986) has added his voice to the poor status of science learning in schools in Africa. In spite of common acknowledgement of the importance of learning, little is known about the manner in which students learn the content that is presented to them in science classes, hence the need for the present study.

In the foregoing section I have described the story of science education from a continental perspective. In the following section I present the story of the development of science education in Malawi to show how continental and local factors interacted to bring about the current situation in science education.

2.5 Science education in Malawi during the post-independence period

A close study of the development of science education in post-independence Malawi indicates an initial vigorous attempt to improve science education, in the light of the recommendations of the Addis Ababa Conference of African States on the Development of Education in Africa, followed by a sudden return to colonial practices. The changes made in science education are presented before the discussion of opposition to the teaching of science in independent Malawi.

2.5.1 Changes made in science education in the post-independence period

In 1964 when Malawi became an independent state, efforts were made to improve the primary school curriculum. UNESCO experts were contracted to produce a new primary school syllabus to replace the 1961 syllabus (Malawi Government, 1966). The UNESCO experts produced a new syllabus in 1966 which is referred in the rest of this work as the 1966 syllabus. The 1966 primary school syllabus was in many respects an improvement over the 1961 syllabus. The guiding principle of the 1966 syllabus was the "scientific spirit of inquiry" (Ministry of Education, 1966, p. 1). Students in Standard 8, which is equivalent to Grade 8 were required to carryout at least one scientific investigation in groups of 4 or 5 students. Such topics as nature of science and contributions of science to medicine, agriculture and other human endeavours were included in the 1966 syllabus.

Another change that was made in the 1966 syllabus that may have affected science education concerns the teaching of English. During the colonial period English was not a mere language, it also functioned as a carrier subject for learning skills. English was hence divided into dictation, comprehension, composition, literature and grammar. These parts of the subject were timetabled to ensure that students would be engaged in task involving them every week. Since independence, these parts of English disappeared from timetables. This means that teachers have to choose when to make students perform tasks relating to them. In schools with many unqualified teachers, the likelihood that all teachers will pay due attention to all parts of English is slim. In the post independence period English became a mere language and no other subject was introduced to carryout the function of communicating learning skills to students. Students' mastery of the language of instruction is an important facilitator of success in science learning (Head and Sutton, 1985; Lemke, 1990; Osborne, 2002, Lyle and Robinson, 2002; Yore *et al*, 2003). Students whose grasp of English is very week cannot do well in subjects that are taught in English. Physical Science is taught in English in Malawi.

2.5.2 Opposition to teaching science in the post independence period

Hawes (1979) noted that the guiding principle of the 1966 syllabus was in conflict with the political aspiration of the rulers of the country. While the rulers wanted to develop a citizenry that would obey instruction without questioning, the science curriculum aimed at producing citizens who would ask questions and "would not be satisfied with any answer" (Kachama, 1972, p. 1). This conflict was resolved through an announcement by the then President forbidding the use of "modern methods of education" (Hawes, 1979, p. 53). Following the announcement teachers were told to use the methods, materials and techniques they had used during the colonial period. Students were advised to obey their superiors without question. The net effect of this incident has been that the teaching of science in primary schools in Malawi has not benefited from the ideas in science teaching that were developed in the 1970s and early 1980s.

A new syllabus for primary schools was introduced in 1982. The 1982 syllabus did not mention the "scientific spirit of inquiry" on which its predecessor was based (Malawi Government, 1966, p. 1). General science which was a combination physics, chemistry, biology and health science was discontinued instead a new subject called science and health education was introduced. Science and health education were allocated 2 periods each. The 1966 syllabus allocated 5 periods to general science in Standards 5 to 8.

The current primary school science syllabus in Malawi combines science and health education in one to one proportion. The previous policy concerning science education allowed girls to drop science and health education to take home economics. The continental resolutions about the importance of science education in primary schools seem to have had little effect in Malawi. It may be conclude that colonial attitudes to science survived the eve of independence in Malawi.

2.6 Conclusion

Malawi, as indicated above, seems to have had administrations that were opposed to the teaching of science during both the colonial and post-independence period. The fear of scientifically educated men and women guided science education policies of the colonial administrators as well as the early post-independence rulers. As Chipembere (2002) states traditions once established in an education system continue to affect the system even after attempts to change the traditions have been made. It is a matter for further investigation to determine whether or not the fear of scientifically educated men and women continues to influence the provision of science education to citizens of Malawi to this day.

Chapter three

Contextualising the problem

3. Introduction

In the previous chapter the history of the problem under investigation was presented. This chapter details the context of the problem. In this chapter a description of the physical and educational context in which the problem was investigated, is provided. The geographical location of the study is Malawi a country that was called Nyasaland before 1964 when it became independent. The purpose of the chapter is to show that although the problem of poor performance in science exists in many countries in Africa (Manyuchi, 1982; Lewin, 1993; Mordi, 1993; Hungwe, 1994) its dimensions in Malawi are such that the country forms a suitable context in which answers to the research questions of this study can be sought. The chapter begins with presentation of information about Malawi as a country. It goes on to present facts about the education system in Malawi and the educational context in which the study was conducted.

3.1 Malawi

Malawi is a small landlocked country in Eastern Southern Africa. It is 900 km long and varies in width from 80 to 160 kilometres. It shares common border with Tanzania to the north and north east, Zambia to the west, and Mozambique to the south. The total surface area of the country is 11.4 million hectares, 2.4 million hectares of which is under water. Malawi's economy is based on agriculture. The main cash crops of the country are tobacco, tea and sugar. Nearly 80% of the people of Malawi are small holder farmers. The population of the country is about 12 million.

Missionaries of the Free Church of Scotland and of the Church of Scotland arrived in Malawi in 1875 and 1876 respectively, and established primary schools. Malawi became a British Protectorate in 1891. In 1964, Malawi became a sovereign state and was ruled by Dr. H. K. Banda for 30 years. Dr. Banda's one party dictatorship came to an end in 1994 when the majority of citizens voted for multiparty democracy as a new political dispensation for the country.

3.1.1 Primary education in Malawi

Provision of primary education in Malawi during the colonial era has been mainly the job of voluntary Christian missionaries. It took the colonial government of Malawi 35 years to take some responsibility for the provision of education to the citizens of Malawi. The lead that missionaries had over the colonial government in the provision of education is a significant factor in the introduction of science in the country's schools. Because of this lead, some missionaries felt that they had the right to exercise the power of veto over some of the country's education policies (Macdonald, 1969).

The formal education system in Malawi, like in other countries, is organised into three major structures: primary, secondary and tertiary. Primary education in Malawi begins at the age of six and takes eight years to complete. Students sit for the Primary School Leaving Certificate Examination (PSLCE) at the end of the primary cycle. The PSLCE serves both as an achievement examination and as an instrument for selection of students that are offered places in Government and Government Assisted Secondary Schools (GGASS). In the 2000, one hundred and thirty-nine thousand and thirty-six students sat for the PSLCE (Malawi Government, 2000 p. 70). Of those who sat for the PSLCE in 2000, only 13,925 were offered places in GGASS (Malawi

Government, 2000, p. 75). This implies that only 10% of the candidates managed to find places in GGASS.

One constant feature of primary education in Malawi is its ever-increasing enrolment. During the colonial period there was uncontrolled founding of unassisted schools (Macdonald, 1969). Establishment of unassisted schools was often fuelled by competition among various Christian missions and did not take into account resources available to the missions. Many schools in the colonial era were, consequently not adequately equipped to provide education to students as previously indicated.

In the post independence period enrolment in primary schools steadily increased, often without corresponding increases in other resources such as teachers, books, classrooms and school furniture (Kadzamira, Nthala and Kholowa, 2004; Heyneman, 1980). The introduction, in 1994, of Free Primary Education Programme (FPEP) resulted in an unprecedented expansion of the primary school system. The FPEP raised the enrolment of primary schools from 1.9 million to 3.2 million (Ministry of Education, Sports and Culture, 2000, p. 10). This expansion of the primary school system necessitated employment of 18,000 unqualified teachers (Ngalande, 2000, p. 2). From their inception to the present time primary schools have been schools under tension in the sense that they have suffered and continue to suffer from lack of necessary resources. The quality of primary education offered in Malawi has hence remained poor as previously indicated. The circumstance, in which primary education in Malawi finds itself, is, in this study, not considered to be a cause of poor performance in science subjects but a reason for setting out to determine how students selected from such primary schools learn physical science when they are offered places in secondary schools.

3.1.2 Secondary education

Secondary education is delivered through two modes of delivery: GGASS and Community Day Secondary Schools (CDSS). As indicated previously places in

GGASS are allocated to students on the basis of the performance in PSLCE. Secondary education lasts for four years and is as in other countries, divided into a junior and senior phase. At the end of the junior phase, a Junior Certificate Examination (JCE) is administered to select those who would proceed to the senior phase. Secondary class 3 students in GGASS, the target population for the study, are hence students who have been selected twice. In 2000 there were 14,627 secondary class 3 students in GGASS and 39,174 in CDSS (Malawi Government, 2000, p. 74).

3.1.3 Tertiary education

Tertiary education is provided by three universities and by post-secondary training institutions. Courses in the universities last anything from 4 years to 7 years after MSCE. Sub degree courses are offered in post secondary vocational training institutions. These courses last for 3 or less years. In 2000, the latest year for which data is available, there were 3,977 students in the University of Malawi and 12,129 in Primary Teacher Training Colleges (PTTC) (Malawi Government, 2000, p. 98 and 102).

3.2 Educational context of the study

Malawi as a site for this exploratory case study is distinguished educationally by low and decreasing literacy scores among primary school students, decreasing numbers of students offering to take science subjects in its secondary schools and low and decreasing pass rates in science subjects in national examinations. Malawi is also distinguished by oscillating science policies. These features that make Malawi a suitable site for the study are elaborated in the rest of this chapter.

3.2.1 Low and decreasing literacy scores

The Southern and Eastern African Consortium for Monitoring Educational Quality (SACMEQ) studies indicate that Malawi's literacy scores for grade six primary schools students are the lowest among the countries of Southern African Development Community (SADC) (UNESCO, 2004, p. 121). Figure 3.1 below adapted from Education for All (EFA) Global Report bears testimony to low attainment of literacy among Malawian children.

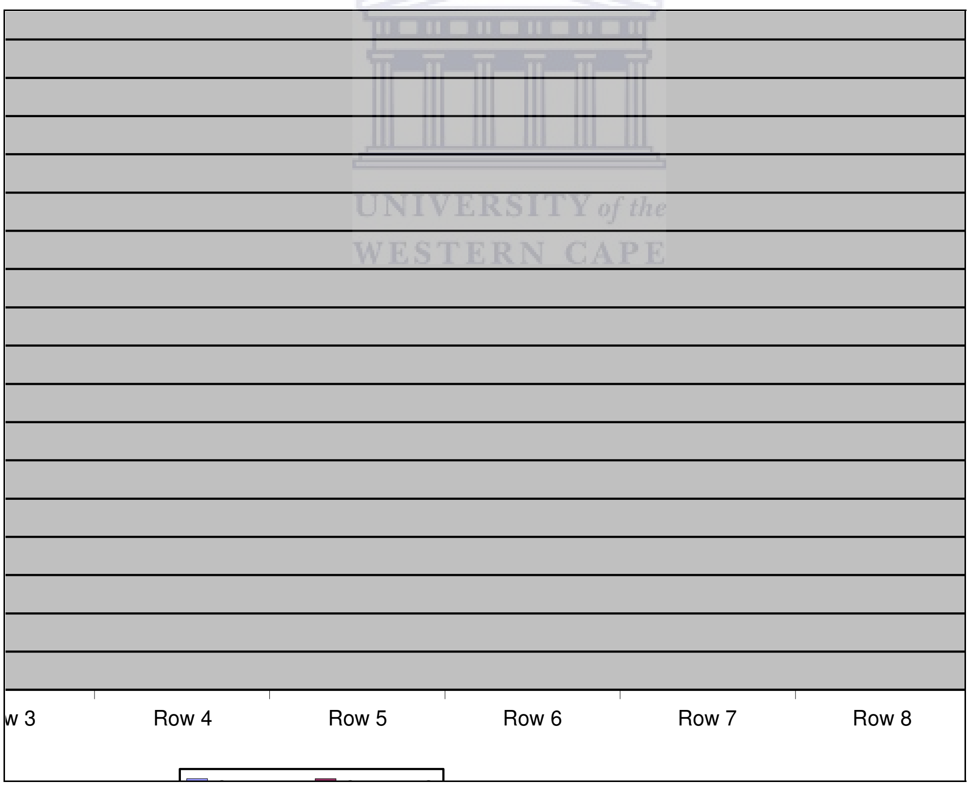

Figure 3.1. Percentage of grade 6 students reaching desired and minimum literacy levels in seven African countries.

The literacy scores of students in primary schools in Malawi shown above are not only the lowest they are also decreasing. A comparison of literacy scores of SACMEQ 1 study carried out in 1995 and 1996 and SACMEQ 2 study that was done in 2000 and 2001 indicates that that literacy scores for Malawian children are decreasing (UNESCO 2004, p. 46). This means that the quality of the products of the education system at primary level is changing for the worse rather than the better.

3.2.2 Decreasing enrolment for science subjects at secondary level

In recent years Malawi has experience a decrease in numbers of students offering to study science subjects. Figure 3.2 below shows numbers of MSCE candidates in conventional secondary schools from 1999 to 2003 for agriculture, mathematics, biology and physical science.

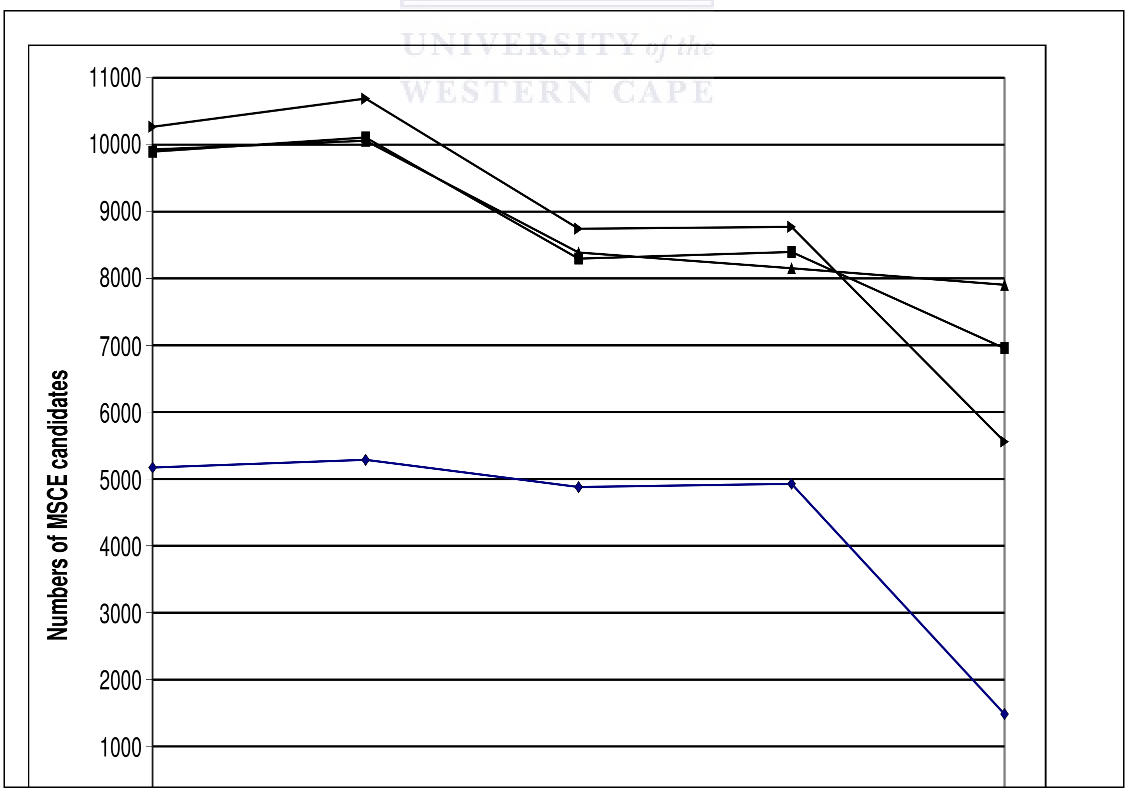

Fig. 3.2 Numbers of candidates in conventional secondary schools in physical science, agriculture, mathematics and biology from 1999-2003.

Conventional secondary schools are comparatively well equipped to teach physical science. The downward trend in the number of candidates was a result of change in government policy. Before 2002 students in these schools were required to take Mathematics and the three subjects depicted in figure 3.2 above. After 2002 students were allowed to choose the science subject that they would like to study. The net-effect of the change in policy concerning optional and compulsory subjects is the decrease in candidature in 2003 in the science subjects. The policy has since been reviewed and all students in conventional schools are currently expected to take physical science.

3.2.3 Oscillating policies concerning science education

Policies concerning science education have in the post independence era changed from one extreme to another. For instance, in 1966 Malawi followed advice of UNESCO experts in science education when it introduced in its schools the 1966 syllabus that was in keeping with worldwide curricula changes initiated in the United States of America in the late 1950s (Kachama, 1972). Cultivation of the spirit of inquiry was the main aim of the syllabus change in 1966 (Ministry of Education, 1966). At the secondary school level Kachama (1972) expressed the hope that the new primary school syllabus would result in increases in "pupils endowed with inquiring minds, pupils who are prepared to ask questions who will not always be ready to accept answers" (Kachama, 1972, p. 2). As indicated previously, Hawes (1979) observes that the emphasis on inquiry in the 1966 primary syllabus was in conflict with the aspiration of the political elite of teaching children to obey without asking any questions. In 1982 the 1966 syllabus was withdrawn and the number of periods for teaching science in primary schools was reduced from 5 to 2. The colonial ploy of combining science with health education as described in Altbach and Kelly (1978) was used to reduce the amount of science taught to children in Malawi again in the post independence period. To this day science taught in primary schools is a combination science and health education on 1 to 1 ratio.

In 2000 further changes were made to the school curriculum that created more disorder. Physical science, biology and agriculture were core subject before 2000 but became optional subjects in that year. One of the consequences of this change in policy is the downward trend in the numbers of students sitting for these science subjects at MSCE in 2003 portrayed in figure 3.2. In the same year 2000 a new core subject called science and technology was introduced only to be withdrawn in 2004 and was re-introduced again in 2005 as an optional subject. These sudden leaps in policy that are followed by reversals of the policies have had the effect of confusing teachers and students. The introduction of science and technology for instance, was taken to siginal the removal of physical science as a subject offered in secondary schools by some teachers and students (Kamangira, Mzumara and Dzama, 2003).

3.3 Conclusion

The experiences of Malawi bear testimony to Ogunniyi's (1986) position about indifference of many African governments to the consequences of the science related policies that they pursue. The frequent changes in policy created environments of uncertainty among teachers and students. This study set out to investigate whether in such environments of uncertainty students who do well in their examinations develop the necessary tools for learning sciences. The following chapter presents the concepts that guided the study.

Chapter 4

Theoretical and conceptual framework

4. Introduction

The previous chapter presented the context in which the study was conducted. This chapter presents the concepts that under gild the study. The central concept of this study is learning. Learning is investigated from a constructivist perspective. Both concepts; learning and constructivism have had their meanings expanded in recent years. The initial concept of constructivism that assumed individual construction of knowledge has had to be fused with the concept of social constructivism to take into account the role of one's society in individuals' construction of knowledge. Similarly the concept of learning has evolved from Plato's stimulated remembrance of innate knowledge of Forms, through Pavlov's stimulus-response pairing, to the current multi-dimensional concept of learning.

Learning science in schools today may not only involve acquiring the content of science but also learning how to learn science, developing meta-cognitive awareness, developing appropriate epistemological beliefs about science, acquiring self-regulated learning skills and gaining self-efficacy beliefs about science learning. These aspects of science learning are parts of the theoretical framework of this study and are explained below to bring out the senses in which they are used in the study. The general concept of learning is explained first and is followed by a discussion of individual and social constructivism. Various aspects of learning science are discussed in the last section of this chapter.

4.1 Development of the concept of learning

The concept of learning has evolved since Plato's days. Understanding of the sense in which this concept is used in this study requires a brief description of its evolution. What follows in the rest of this section is an examination of the concept from the perspectives of the ancient philosophers, the behaviourists, cognitive psychologists and the social psychologists.

4.1.1 Ancient philosophers' views of learning

Plato argued that since all objects are constantly changing, they cannot be known, for knowledge of an object, implies existence of essential unchanging characteristics in that object (Ackermann, 1965; Lucas, 1972; Robinson, 1986; Leahey, 1987). To explain human acquisition of knowledge, Plato postulated the existence of a world of Forms. The Forms are perfect unchanging objects of which the objects that one sees in the ever-changing world are imperfect imitations or instances. In Plato's formulation of knowledge, a cat that one sees, for instance, is an imperfect imitation of the perfect unchangeable Cat that exists in the world of Forms. Learning according to Plato is acquiring knowledge of the characteristics of the Forms. Plato's theory of knowledge and learning is important in this study because there is a sense in which subsequent developments in understanding learning and knowledge can be considered to be mere adding of "a series of footnotes to Plato" as Whitehead observed (Whitehead quoted in Lucas, 1972, p. 77). Phillips and Soltis (1985) concur with Whitehead when they observe in this connection that "The ancient Greek is not so easy to dispose of" (p. 30). The authors mean that what Plato said about learning can be ignored but can not be easily disposed of.

The following tenets summarise Plato's position on knowledge and learning.

- Knowledge is innate, it is present in children's minds at birth
- Knowledge is certain and unchanging
- All knowledge is recollection
- Knowledge is not conveyed by the senses but by reasoning about sense data
- Learning is recalling knowledge that is already in the mind through dialectical reasoning
- Objects of knowledge are not physical objects
- Some people are more able to stimulate recall of their knowledge than others

Ideas in the development of knowledge of human learning have gravitated around the tenets listed above. As indicated in the tenets, Plato gave the senses no role in learning. Knowledge according to Plato is acquired only through dialectical reasoning. The British philosopher John Locke rejected the idea that knowledge is innate and argued that ideas that people have come from experience or from reflecting on objects given to their minds by the senses (Hamlyn, 1970). Locke's contribution paved the way for the development of human senses based concept of learning. In

Locke's formulation of learning, the mind plays the same role as it does in Plato's formulation. In later development of human learning efforts were made to dispense with the mind altogether. In the following section, the contributions of the psychologists who sought to reduce learning to observable behaviour are presented.

4.1.2 The behaviourists

To appreciate the role of the behaviourists it is important to understand the circumstances that brought their work about. For this reason, a discussion of the status of psychology as a science subject at the beginning of the 20th Century is presented before presentation of the contributions of the behaviourist psychologists to human learning.

Psychology at the beginning of the 20th Century

At the beginning of the 20th Century psychology found itself in Kuhn's pre-paradigmatic state of development (Kuhn, 1970). There were in America two competing paradigms structuralism and functionalism. Structuralism was a school of psychology based on the works of Wilhelm Wundt of Germany and Edward Tirchener of the United States of America (USA). Psychology under structuralism was devoted to studying mental experiences through analysis of sensations, ideas and feelings using the method of introspection (Colman, 2001). Introspection was a method in which a researcher examined, recorded and described their internal mental processes and experiences. Functionalism, on the other hand, examined both mental experiences and behaviour from the perspective of value in adapting the organism to its environment. Functionalism was an attempt to apply Darwin's theory of evolution to human behaviour. Functionalism saw the human capacity to think as an adaptive mechanism that enables human beings to escape from danger by predicting hazards before they occur.

Against the background of these competing schools of thought in the USA were the development of positivism in Europe and the unprecedented success of the physical sciences in explaining physical phenomena. Ernst Mach followed Hume in arguing that there is nothing we can know beyond analysis of our sensations (Garrison, 1996). Auguste Comte the French philosopher who is popularly known as the father of positivism suggested that human thought develops in three stages namely: the theological, the metaphysical and the positive (Ruggiero, 1959). At the theological stage human beings think in terms of supernatural beings and attempt to gain favours from them through worship or prayer. At the metaphysical stage abstract rational concepts are used to explain physical phenomena. It is, however, at the positive stage where facts are understood with certainty and their connections to other phenomena are appreciated. The purpose for seeking knowledge according to adherents of positivism was to have a useful guide for one's conduct and to be able to control forces in nature for the good of everyone.

Otto Neurath, one of the founders of logical positivism expressed the central belief of the positivism when he wrote that "The body of scientific propositions exhausts the sum of all meaningful statements" (Otto Neurath quoted in Leeahey, 1987, p. 5-6). What Neurath says in the preceding quotation is that only scientific statements are meaningful, all other statements are meaningless. It was against this background of unrivalled success of the physical sciences in explaining and predicting natural phenomena and as it were, an ailing psychology that could not settle its internal disputes, that the behaviourists reacted to. Behaviourism was, however, not a unified school of thought. There were varieties of behaviourism. The discussion that follows is limited to works of Watson, Pavlov, Thorndike, Skinner and Tolman.

Contributions of behaviourism to the concept of learning

The behaviourists were completely filled with the spirit of science (Phillips and Soltis, 1985). The spirit of science is evident in Watson's article of 1913 on psychology as the behaviourist views it. In that article Watson sought to elevate psychology from a pre-paradigmatic science to "a purely objective experimental branch of natural science" (Watson, 1913, p. 1). Watson's article is worth quoting at length.

> Psychology as the behaviourist views it is a purely objective experimental branch of natural science. Its theoretical goal is the prediction and control of behaviour. Introspection forms no essential parts of its methods, nor is the scientific value of its data dependent upon the readiness with which they lend themselves to interpretation in terms of consciousness. The behaviourist in his efforts to get a unitary scheme of animal response, recognizes no dividing line between man and brute. The behaviour of man, with all its refinement and complexity, forms only part of the behaviourist's total scheme of investigation (Watson, 1913, p. 1).

In the excerpt above Watson adopts the positivistic aim for acquiring knowledge as the theoretical aim of behaviourist psychology. He also distances behaviourist psychology from structuralism and functionalism. Elsewhere in his paper, he writes "I have done my best to understand the difference between functional psychology and structural psychology. Instead of clarity, confusion grows on me" (Watson, 1913, p. 4). Watson further called on psychology to give up references to consciousness and to stop thinking in terms of the mind. In dismissing the mind as an object of psychological inquiry, Watson asserted more than his premises would allow him but as Phillips and Soltis (1985) maintain, the behaviourists may have been misled by their commitment to the spirit of science. It is the works of Skinner and Tolman among the behaviourists that made lasting contributions to the concept of learning. Skinner's work is presented first and is followed by Tolman's work. Tolman's work forms a link between behaviourism and cognitive approaches to learning.

Pavlov, the Russian physiologist who was awarded the Nobel Prize in 1904 for his work on digestion made two contributions to the growth of behaviourism. His discovery that that the dogs that he and his assistants fed salivated on merely seeing him or his assistants opened up a new area of study called classical conditioning or respondent learning (Eggen and Kauchak, 1994). Pavlov's work contributed knowledge to be used in building a scientific account of animal behaviour. More importantly, his work provided an alternative method to introspection the then dominant method of psychology (Kimble, 1992). Classical conditioning led to the stimulus-response psychology that emphasized manipulating the stimulus for behaviour in order to make its response occur.

Skinner felt that responses to specific stimuli accounted for a negligible proportion of the behaviour of human beings or animals. He suggested that behaviours of organisms would be better controlled by manipulating their consequences rather than their antecedents. A consequence of behaviour is "an outcome occurring after the behaviour that influences future behaviours" (Eggen and Kauchak, 1994, p. 262). Skinner called learning that occurs due manipulation of consequences operant conditioning implying that the learner is operating on the environment. Skinner found that behaviour that is followed by reinforcement increases in frequency of occurrence. Reinforcement is anything that increases either the frequency or duration of behaviours. He also found that behaviour that is followed by disliked condition tends to decrease in its frequency of occurrence. Thorndike arrived at similar conclusions (Phillips and Soltis, 1985). In general, the behaviourists rejected Plato's position that learning occurs because there is something in the mind that is stimulated to consciousness through thought. Their position is that learning occurs, because like Pavlov's dogs, human being are "wired" so that behaviour that is reinforced has a greater chance of occurring than that which is not reinforced (Phillips and Soltis, 1985). To the behaviourists learning is acquisition of new behaviour.

Skinner's work has had implications for shaping behaviour and reinforcing learners. As Tobin, Tippins and Gallard (1994) observe reinforcement of learners in classrooms today takes the form of assessing, judging and rewarding learners. The authors report:

> Unless an activity was assessed, it was difficult to obtain the active participation and cooperation of students. The effect of this trend was an

> emphasis on completing products for grades. There seem to be an implicit bargain in the culture that students would work for grades in much the same way that employees work for pay. Students focused on completing tasks and getting the grade, and learning became a by-product of the main activity in the culture (Tobin *et al*., 1994, p. 84).

According to the excerpt above, grades are the currency in which students get paid for the work they do. Learning is the by-product of the scramble as it were, for grades. Although the authors argue from a constructivist perspective that grades-centred teaching would not be conducive to learning science with understanding, frequent assignments and testing seem to be indispensable in facilitating science learning. The frequency at which assignments and tests are given or administered to students is hence one of the factors that this study investigated.

Tolman was an exceptional behaviourist in the sense that he held cognitively orientated ideas in a camp of behaviourists. Although Tolman accepted Watson's position that the ultimate aim of psychology is prediction and control of behaviour (Leahey, 1980), he differed with Watson in as far as he rejected mere stimulus-response pairing as a sole explanation of behaviour. He saw the minds of rats and human being through mental processes that he thought could be operationally defined as intervening variables. He held that when a rat is set free to move around a maze, a field map of the maze gets established in the rat's brain so that its behaviour in the maze is guided by its mental map. Thus Tolman's work anticipated cognitive approaches to learning that were developed later. Cognitive approaches to learning are discussed next.

It has to be pointed out that Tolman was not the only behaviourist who found experimental evidence that suggested the importance of the nervous system in controlling behaviour. In his article on the history of experimental analysis of operant behaviour Skinner (1998) reports:

> Various physiological states and processes intervene between the operations performed on an organism and the resulting behaviour. They can be studied with appropriate techniques, and there is no question about their importance. A science of behaviour has its own facts, however, and they are too often obscured when they are converted into hasty inferences about the nervous system (p.295).

The processes that Skinner in the excerpt above says "intervene" between operations performed on an organism and the behaviour of an organism are the observations that made Tolman to adopt a cognitive perspective. Skinner elsewhere in his paper says he would still say what he said in The *Behaviour of Organisms* a book he published in 1938, that "no physiological fact has taught us anything about behaviour that we did not know" (Skinner, 1998, p. 295). It seems from the excerpt above that contradicting evidence was ignored for the sake of maintaining a science of behaviour. Leahey (1980) compares Skinner's doing away with the mind with Aristotle's doing away with Plato's Forms.

4.1.3 Contributions made by cognitive psychologists to the concept of learning

Apart from Tolman's cognitive behaviourism that has been previously referred to, there was in the 1920s the work of Wolfgang Kohler that supported cognitive approaches to learning. Kohler argued that Thorndike had placed his experimental cats in a "no win situation" in the sense that even if the cats were capable of displaying intelligent behaviour, they would not display it because the experiments excluded at the design stage all possibilities of observing intelligent behaviour. In Kohler's view Thorndike had in his experiments already eliminated the possibility of observing intelligent behaviour. Kohler felt that the conclusions that Thorndike drew from his experiment were suspect and set to find out whether Chimpanzees would display intelligent behaviour when placed in a suitable environment. From his experiments with Chimpanzees on the island of Tenerife, Kohler found that the animals do display intelligent behaviour and concluded that learning takes places through insights (Phillips and Soltis, 1985). For insightful learning to take place, the following conditions must be fulfilled:

- The learner must be familiar with elements of the problem and its solution
- Elements of the solution to the problem must be available to the learner
- The learner must have access to the overall problem situation

Kohler rejected Locke's atomistic view of learning that maintained that human minds receive simple ideas that are subsequently combined with other ideas to form complex ideas. Kohler's position is that human beings experience the world in meaningful wholes. Leahey (1980) maintains that the psychology that grew out of Kohler's work, Gestalt psychology, was never a serious competitor of behaviouristic psychology in the USA. The development of the information processing metaphor of learning that occurred in the late 1950s and early 1960s presented more evidence for the cognitive approaches to learning. The information processing model of learning is presented in the following paragraph.

Cognitive theories are explanations for learning that focus on the internal mental processes that human beings use to make sense of events in the physical world (Eggen and Kauchak 1994). As Mayer (1992) notes, in the early 1960s a new metaphor of learning known as information processing metaphor, based on concept of learning as acquisition of knowledge, superseded the change of behaviour-metaphor that had dominated thinking about learning for more than half a Century. In the new metaphor learners became processors of information. Researchers under the new metaphor of learning attempted to picture events that took place in learners' minds from the moment they receive sense impressions from their environments to the time they respond visibly through some behaviour (Thomas, 1995). The initial goal of instruction in the information processing view of learning was to increase the amount of knowledge that learners had. Evaluation of learning under the information processing paradigm amounted to measuring amount of knowledge acquired by a learner (Mayer, 1992). The information processing model of learning has made a number of contributions to the present day concept idea of learning. The model has provided knowledge structure of human memory. It has also drawn attention of teachers to need to organise information to be presented to students in a small number of units called chunks to facilitate learning. Furthermore the information processing model has clarified the manner in which mnemonics function in facilitating learning through memorisation.

In the late 1970s and early 1980s another model of learning within the cognitive formulation called learning for conceptual change was proposed. Some researchers in science education began to use the technique of interviewing students to determine what students knew about certain science concepts before and after instruction. Findings from this kind of research indicated that many students had pre-instructional intuitive models of scientific concepts that resisted change. Students' intuitive concepts were variously called children's ideas, children's science, misconception or alternative frameworks. For reviews of these studies see Driver and Easley (1978), Driver and Erickson (1983), Osborne and Freyberg (1985), Driver, Guesne and Tiberghien (1985), Pfundt and Duit (1991), Dykstra, Boyle and Monarch (1992), Driver, Squire, Rushworth and Wood-Robinson (1994) and Wandersee, Mintzes and Novak (1994). The proceedings of the conference on misconceptions that was held at Cornell University in 1983 contain numerous studies of misconceptions or alternative frameworks from around the world (Helm and Novak, 1983). From this work a new concept of learning, learning as conceptual change, emerged. Suggestion as to how teaching should be conducted to achieve conceptual change, were published in the science education literature (Gilbert, Osborne and Fensham, 1982; Posner, Strike, Hewson and Gertzog, 1982 and Strike and Posner, 1982). According to these authors to achieve conceptual change learning, the following conditions should be fulfilled:

- Learners must be dissatisfied with their existing conceptions
- The new conceptions must be such that they can be understood by the learners
- The new conception must be such that they make sense to the learners

- The new conceptions must be fruitful

Teaching models based on the conditions indicated above were suggested and implemented but it did not take long to realise that the conceptual change model had its limitations. Dissatisfaction with the conceptual change model led to the development of the constructivist model of learning. Since the constructivist model forms the overarching frame it is discussed more fully in the rest of this chapter.

4.2 Constructivist concept of learning

The constructivist model of learning is a variant of the cognitive approaches to learning. In the constructivist model as West (1988) states "learning involves constructing one's own understanding of reality, making one's own sense of other people's understanding of the world" (p. 59). Similarly Wittrock (1985) posits that learning in this model involves generation of meaning on the part of learners. The fact that construction of meaning can take place in a small group or in an individual's mind has given rise to social and individual constructivism. Both social and cognitive constructivism are used in this study and this section begins with a discussion of these terms to show how they have been used. Other concepts that have emerged from the constructivist view of learning and inform this study are situated learning, self-regulated learning, metacognition, epistemological beliefs and self-efficacy and, attribution of success or failure. These concepts are also explained below.

4.2.1 Individual and social constructivism

The dividing line between social and individual constructivism is an either or answer to the question: is knowledge mainly an individual or a social construct? Scholars such as von Glaserfeld (1981, 1989, 1993); Wheatley (1991); Driver, Asoko, Leach, Mortimer and Scott (1994); Duit and Treagust (1995); Tobin (2004) seem to consider knowledge to be mainly an individual's construct. These authors assert that individuals actively construct their knowledge. They also agree with Ausubel's (1968) dictum that the most important thing affecting learning is what the learners already know. Other scholars notably Vigostsky (1962), Greeno, (1992), Daniels (1993), Wertsch and Smolka (1993), Wells (1999) and, Packer and Goicoechea (2000) seem to maintain that knowledge is mainly a social construct. To them learners construct their knowledge through interactions with teachers, other learners, materials and through observing and exploring things. More recently, attempts have been made within science education to move away from "monistic" views of learning to borrow a word from Duit and Treagust (Duit and Treagust, 2003, p. 680). Tobin *et al*. (1994) for instance write:

> All knowledge is constructed. Accordingly, social and cultural phenomena are also personal constructs. However an individual is born into a social and cultural environment in which all of the objects and events that are encountered have particular meanings that were also constructed. Through interactions with the living and nonliving components of the milieu in which an individual is raised, all learning is socially mediated. Accordingly, knowledge has a social component and cannot be seen as constructed by an individual alone (p. 47).

The main point Tobin *et al*. raise in the excerpt above is that when thinking about human learning, it wrong to think only about one variable to the exclusion of other variables. In the view of these authors, individual, social, environmental, cultural and material factors play roles in human learning and should be given due consideration.

Among physicists it is common knowledge that thinking in terms of either or is not always helpful. The particle-wave duality of light demonstrates the futility of thinking about light in either or terms (Ohanian, 1985, p. 912). I have in this study, concurred with Cobb (1994), Salomon and Perkins (1998) who have attempted to reconcile social and individual constructivism. Salomon and Perkins (1998) consider knowledge to be equally an individual and a social phenomenon. Social learning to them is "a meaningful concept sufficiently distinct from individual learning to warrant attention" (p. 16). "Dismissing the notion of individual learning all together" Salomon and Perkins (1998, p, 17) continue "would be to throw out the baby with the water by blurring important distinctions". The implication here is that both concepts are necessary if learning is to be understood more fully. I have chosen to study learning in this study from both the individual and social cultural perspectives. I have, however, adopted a wider scope for things that students construct than is usual in science education, as indicated in the following paragraphs.

What is constructed by individuals is not only knowledge of the physical world. Packer and Giocoechea (2000) express this point succinctly.

> To the constructivist emphasis on the active learner must be added recognition that knowledge is not all that is constructed. The human individual is a construction too, as is the social world. Constructivism fails to see that the individual cognizer is not a natural creature but one possible creation of human culture and history. The cognizing individual and the inner realm of the mind are not natural, they are bittersweet fruit of particular social arrangements (p. 235).

In the excerpt above Packer and Giocoechea are saying that learners do not only construct knowledge, they also construct themselves using information that is available to them. The study assumes that differences in performance of students in different schools may be a consequence of the kinds of constructs students construct about themselves as learners. Such constructs depend upon the environment in which the students find themselves.

Osborne (1996) observes that the idea of situated cognition as elaborated by Lave (1988), Brown *et al*. (1989) and Lave and Wenger (1991) is merely a strong form of social constructivism. Central to situated cognition is the notion of legitimate peripheral participation. To explain the concept of legitimate peripheral participation, it is necessary to divert and present an explanation of Kuhn's (1970) concept of a paradigm.

According to Kuhn, science develops in cycles consisting of six periods namely; pre-paradigm, normal science, anomaly, crisis, revolution and normal science. During the pre-paradigm period there no science and only random fact gathering takes place. During normal science one paradigm is accepted and scientists get involved in puzzle solving activities until anomalies begin to occur. Anomalies are observations that cannot be explain by the ruling paradigm. When anomalies accumulate, a crisis occurs. In a crisis, the ruling paradigm is challenged and contending theories emerge. During a revolution a new paradigm is advanced and young scientists adhere to the new paradigm while some older scientists switch allegiance. A paradigm is a community of scientific practitioners and the "world" inhabited by its members (Packer and Goicoechea, 2000, p. 231). A novice in scientific profession begins on the periphery of the profession and moves to the centre of the profession through training. Thus the idea of legitimate peripheral participation denotes the process of progressing from an aspiring recruit to a certified professional.

When the concept of legitimate peripheral participation is applied to schools Brown *et al*. (1997) and Gregory (2002) suggest that schools should be considered to be communities where students learn to learn. This study takes the central function of schools to be teaching students how to learn. The study acknowledges the importance of subject content in teaching students how to learn.

4.2.2 Other aspects of constructivist model of learning

Situated learning

According to *The Concise Oxford English Dictionary*, the word situate has two senses of meanings. In one sense of this word means putting things or persons in a certain position or circumstances. Thus a house for instance can be said to be situated on a hill. In the second sense, situate means putting things or persons in a context that has the potential of affecting them in some way. Learning that takes place in schools in the developing countries is likely to be affected by the very context in which it takes place. Beliefs that students may develop about themselves as learners and about the nature of knowledge for instance, may be forced upon them by the context in which they are learning or the by their social cultural environment. Cobb (1994) states in this connection that it is inappropriate to single out qualitative differences in individual thinking apart from their social cultural situation "because the differences in students' interpretation of school tasks reflect qualitative differences in the communities in which they participate" (p. 15). Assuming with Watson (2001) that the function teachers is to provide students with a conceptual foundation for future learning, the concept of situated learning was used to draw the attention of the researcher to those factors in schools that are beyond the students' or teachers' control but which nevertheless affect students' learning.

Learning skills or strategies

Learning skills act as academic enablers. They are tools for enabling students to acquire knowledge and enhance their mental competence (Gettinger and Seibert, 2002). Two types of learning skills can be identified: activity learning skills and regulatory or control level skills. Activity level learning skills are the things that students perform to learn something. Such activities as reading, making own notes, thinking through a problem, working out a mnemonic, elaborating, doing an experiment, problem solving, working out exercises or discussing a topic with peers are skills at the activity level of learning. Regulatory or control level skills involve planning, monitoring and controlling and reflecting on learning activities. Learning skills that have to do with regulating, monitoring, reflecting and planning are called meta-cognitive skills (Gunstone, 1994). Presseisen (1992) defines meta-cognition as the "learners' knowledge or awareness of his or her own cognitive processes and products and the ability to regulated them" (p. 3). Most definitions about metacognition including the preceding one can be criticised for circularity in the sense that part of the word that is being defined occurs in the definition. There are according to Masi, Brovedani and Poli (1997) three interrelated components of metacognition. These components are:

- Awareness about one's own mental processes and knowledge
- Capacity to manage strategically one's tools for gaining knowledge and acquiring skills
- Beliefs or theories about the functioning of ones mind

This study focused on the second component of metacognition in the sense that it sought to determine whether the students were able to relate learning tasks to suitable skills or simply used the same skill every time.

When learning skills are integrated and used by students "with a purpose in view" they become learning strategies (Nisbet and Shucksmith, 1988, p. 6). The integrated series of learning skills used by students in a particular subject may not be appropriate for the tasks that the student would like to accomplish. Hence the need to determine the skills they use and whether they match tasks with appropriate skills.

Epistemological beliefs

Epistemological beliefs are individual's understandings about the nature of knowledge and the nature of learning. Hofer and Pintrich (1997, p. 117), define epistemological beliefs as individuals' conceptions "about the nature of knowledge and the nature or process of knowing" (p. 59). Similarly, Jehng, Johnson and Anderson (1993) take epistemological beliefs to be socially shared intuitions about the nature of knowledge and the nature of learning. Clarebout, Elen, Luyten and Bamps (2001) consider epistemological beliefs to be learners' identifiable conceptions about the nature of knowledge and learning. These conceptions have been shown to affect students' achievement in learning science as indicated in the following paragraph.

Epistemological beliefs interact with instruction to determine students' learning outcomes. In his seminal paper Schoenfeld (1983) showed that "one's belief system plays an important part in determining ones cognitive performance" (p. 352).

Schommer (1990) uses the term "personal epistemology" to refer to Schoenfelf's "belief systems". Schommer hypothesises that personal epistemology may be composed of multiple beliefs and each belief may have a different effect on learning. There is empirical evidence that epistemological beliefs influence academic performance (Schommer, 1990, 1993; Schommer and Walker, 1995; Paulsen and Feldman, 1999; Schommer, Mau, Brookhart and Hutter, 2000; Youn 2000). According to Schommer (2004) some epistemological beliefs are indicative of dysfunctional attitudes and practices in learning in school. The dysfunctional epistemological beliefs that Schommer identifies are certain knowledge, fixed ability to learn science, simple knowledge and quick learning. Research on epistemological beliefs indicates that these beliefs affect learning as well as problem solving behaviour among students (Youn, 2000; Dweck and Legget, 1988). Qian and Alverman (2000) state that students, who believe in fixed ability to learn, simple knowledge and quick learning tend to avoid obstacles, resort to ineffective learning strategies and are unlikely to persist in the face of difficulties. Epistemological beliefs can hence be used to study students' possible responses to learning tasks and to distinguish between good and poor students. Epistemological beliefs are in this study, beliefs about the nature of knowledge and science learning. Some authors such as Vrumuku (2004) prefer to confine epistemological beliefs to beliefs about knowledge of science arguing that epistemology is the study of the nature of knowledge. The interrelatedness between epistemological beliefs and learning skills, however, made it necessary for this study to opt for the broader definition.

Nature of science

The main purpose of science education in secondary schools is to enable students to engage in scientific reasoning to solve problems, carry out scientific investigations and generate knew knowledge. School science as Parkinson (1994) and Harlen (1996) note, has in the past been presented in schools as lists of facts, statements, rules or laws to be committed to memory. Furthermore school science presents to students an image of science as knowledge that has been shown to be true and remains so for all the time. Millar writes, in this connection about portraying school science as "a body of established knowledge that cannot be contested" (Millar, 1997, p. 92). The nature of science debate in science education aims at communicating to students an adequate concept of science to promote science literacy. According to Solomon (1997), a person is scientifically literate when they are knowledgeable about science and are able to respond to messages about it. Scientific literacy means being able to use scientific reasoning to solve problems besides being able to generate new knowledge and appreciate the strengths and limitations of science. For a person to be scientifically literate they have to understand the nature of science. Lederman (1992) defines "nature of science" as values and assumptions inherent to development of scientific knowledge (p. 331). In a more recent paper, Schawartz, Lederman and Crawford (2004) define nature of science as values and underlying assumptions that are intrinsic to scientific knowledge, including influences and limitations that spring from the human nature of the scientific endeavour. Although consensus about the necessity of teaching students nature of science is emerging, there has been little agreement about the individual aspects of science that should be taught (Alters, 1997; Smith, Lederman, Bell, McComas and Clough, 1997; Niaz, 2000; Bartholomew and Osborne, 2003). The absence of consensus on the aspects of science that should be taught in schools raises to the fore, the possibility that the students may have inadequate ideas a bout the nature of science to support their learning. Nature of science in this study means what the students think science is.

Self-efficacy beliefs

Given the long history of poor performance in science, it is necessary to find out whether the students think they can succeed in learning science. As Bandura's social cognitive theory stipulates, people's judgements of their capabilities, strongly influence the choices they make, the effort they expend, and how long they persevere in the face of challenge (Bandura,1977, 1997; Pajares and Miller, 1994). Bandura's self-efficacy theory claims that "if people believe that they can control the outcome of their behaviour, then they can" (Franzblau and Moore, 2001, p. 83). In Bandura's analysis, how people behave can often be predicted from their beliefs about their capabilities than from "what they are actually capable of accomplishing" (Pajares and Miller, 1994, p. 193). An individual's belief in his or her ability is called self-efficacy. Self-efficacy is defined formally as the individual's assessment of his or her ability to perform specific tasks. Self-efficacy beliefs are derived mainly from an individual's past experiences (see Zimmerman, 1997). Determining students' self-efficacy beliefs about learning science hence amounts to exploring their past experience in learning science to find out whether such experiences were contributory to a negative or positive self-image as learners of science.

This study assumes with Greve, Anderson and Krampen (2001) that the development of self-efficacy represents a central aspect of development in adolescence. Greve et al. (2001) offer three reasons in support of their argument about the centrality of self-efficacy in the development of adolescents. First, self-efficacy is a strong predictor of "intention and, hence, of behaviour" (p. 322). Bong and Hocevar (2002) add that as learners' subjective confidence for successfully carrying out learning tasks, self-efficacy bears a critical influence on all aspects of student learning. Second, the self-perception of personal efficacy is a "core aspect of the individual's self-concept" (P. 322). Thus, students with a strong sense of self-efficacy are more likely to choose challenging academic tasks, use effective learning strategies and show greater persistence in the face difficulties (Bong and Hocevar, 2002; Pintrich and DeGroot, 1990; Zimmerman et al., 1992; Bandura, Barbaranelli, Caprara and Pastorellio, 1996; and, Bandura, 1997). Third, the development of self-efficacy and self-concept combine to form a central aspect of personality. Bandura (1997) concurs with Greve et al. (2001) when he states that one's ability to realise desired outcomes and forestall undesired ones plays a critical role in determining one's subsequent functioning, adaptation and attainment.

Academic self-efficacy is an aspect of personal self-efficacy. Bong (2002) defines academic self-efficacy as "the individual's convictions that they can successfully carry out given academic tasks at designated levels" (p. 133). Like personal self-efficacy, academic self-efficacy is derived from past experience (Bandura, 1997; Fouad and Smith, 1997). Bandura (1997) maintains in this regard that failures, especially those failures that occur before a sense of efficacy is established undermine the establishment of self-efficacy. Successes according to Bandura (1997) "build a robust belief in one's personal efficacy" (p. 3). The individual's sources of self-efficacy information are according to Ottingen, (1997) susceptible to cultural influences. Cultural influences may have a negative effect on the development self-efficacy in learning science. Students who have been subjected to experiences of failure in learning science may be further disadvantaged by a culture that hinders the development of self-efficacy in learning science. Self-efficacy in this study means students' beliefs in their ability to succeed in science in national examinations.

Attributions of success or failure

In their course of schooling, students seek to understand causes of success or failure in academic tasks. As Mayer (2003) points out, students may ascribe their success or failure to such causes as ability, effort, task difficult or mere luck. These causal ascriptions of success or failure in academic tasks are called attributions. Attributions may be classified into three dimensions namely: locus of control; stability and controllability (Stapleton, 2001). Locus of control is concerned with whether or not the students perceive themselves as being in control of success or failure in academic tasks. Stability refers to the permanance of the cause of failure or success in academic tasks and controllability is related to the extent to which students believe they can influence success ro failure in academic tasks.

The most important aspect of the attributional theory in students learning lies in understanding the types of reasons that students give "for their failure" (Stapleton, 2001). Students' attributions of success or failure determine their likely responses to failure in academic tasks. If they think that they can influences the consequences of their academic engagements, they are likely to react differently to failure than if they think they cannot influence such consequences. This study sought to determine whether the students in Malawi believe they can influence their failure in physical science by examining the factors that the students claim account for their failure.

4.3 Conclusion

This chapter has traced the development of the concept of learning from the time of the Greek civilisation to the present time. I have shown that the general trend has been to move away from "monistic" conceptions of learning, to borrow a word from Duit and Treagust (2003, p. 680), to a multi-perspective conception of learning. This study adopts the multi-perspective of learning whose elements have been explained above. The next chapter reviews the pertinent literature to the problem.

Chapter 5

Review of the literature

5. Introduction

In this chapter, a brief review of the pertinent literature to the problem is presented. The reviewed literature falls into three broad categories. The categories are: literature on the problem of poor performance in science in Malawi and other African countries; literature on the problem of poor performance in science among ethnic groups in other parts of the world and literature on learning science. The general purpose of the review is to tease out from experiences of scholars the basic characteristics of the problem that is being investigated and its possible solutions.

5.1 Performance of students in science in Malawi and in other African countries

The separation of Malawi from Africa in the title of this section is deliberate. It is meant to convey the different roles the reviews of the literature in Malawi and in other African countries played in providing the base for answering the research questions of the study. Whereas the review of the literature in Malawi defines the problem, the review of the literature in other African countries widens the scope of the problem and provides examples of successful interventions that have been undertaken to alleviate it.

5.1.1 Performance of students in science in Malawi

Studies done in Malawi to investigate the problem of poor performance in science can be classified into two categories: general studies and specific studies. General studies are studies that sought to address more than one variable. Among general studies are: Kimble's (1968) comparison of school and non-school children; Dzama's (1984) factors affecting performance in Physical Science; and, Dzama and Osborne's (1999) poor performance in science. Specific studies are those studies that addressed one variable. In the group of specific are: Case's (1968) study of language barrier in science teaching; Kamwendo's (1984) attitudes to science; Kunje's (1988) cognitive ability and curriculum demands mismatch; Mitchell's (1993) perceived relevance of science; and Mbano's (2003) cognitive acceleration intervention. One study in each category is reviewed and critiqued in the following paragraphs. The studies that are reviewed are Kimble (1968) and Mbano (2003). These two studies have been chosen for in depth review because of the thoroughness that is portrayed in their reports.

In his background concept study of children in Malawi, Kimble (1968) sought to compare school and non-school going children in the development of concept areas that were considered necessary for growth of scientific thinking. Some of the concept areas compared were electric circuits, cause and effect and balancing of masses on the arms of a lever. His sample consisted of 576 school going and 61 non-school going students. The school going students were drawn from 6 schools, two from each region of Malawi. In each school 12 students from each grade took part in the study. Since there are 8 grades in primary education in Malawi, the total number of students who participated in the study per school was 96. The students were chosen in each school in such a way that the number of girls was equal to the number of boys. The participating students were chosen purposively to represent strong, average and weak students. There were two students in each category.

The non-school going children were selected at random in market places on market days. Only those non-school going children whose age ranges corresponded with the school going children participated in the study. School going children in the first five grades and all non-school going children were interviewed in their mother tongues. Measures were taken to exclude from the study all non-school going children who had attended school regularly before the study.

Various research techniques were used to compare the performance of the children on the selected tasks. To determine the children's sense of cause and effect, for example, the story presented below which is derived from stories used by Jahoda (1958) in similar studies in West Africa was related to children to determine their understanding and interpretation of it.

> Aliki and Safira go to the market. Aliki steals some bananas when the seller is not looking. When the children return to their home, Aliki's mother asks him to cut some fire wood with an axe. While he is working, the axe misses the wood and cuts his foot (Kimble, 1968, p. 12).

After relating the story to the child, the child was then asked to answer the following questions.

- Why did Aliki cut his foot?
- Would he have cut his foot if he had not stolen the bananas?
- Did the axe know that Aliki stole the bananas?

Kimble (1968) suggests that those children who have developed a scientific concept of cause and effect and the idea of chance or probability would answer that Aliki was careless or was just unfortunate that he cut his foot. When Kimble compared the scores of the school going and non-school going children grade by grade according to their ages, he found no significant differences. He also found that the number of years the children received instruction in science in schools bore no significant relationship to the scores they achieved on the tests he administered (Kimble, 1968, p. 20).

Kimble's study raises fundamental questions about science education in Malawi at primary school level. It is generally held in religious circles that anyone who commits evil acts will somehow be punished. For instance, the Bible in the book of Acts relates a story of Paul on the island of Malta where a snake bit him. Paul was then a prisoner proceeding to Rome for trial. When the inhabitants of the island saw the snake hanging from Paul's hand they said "This man must be a murderer; for though he escaped from the sea, justice has not allowed him to live" (Acts 28:4). Paul had just escaped from a shipwreck. The thinking of the inhabitants of the island was that although Paul had escaped from the shipwreck, natural justice had not allowed him to live because he was then going to die of snake bite. In addition, the idea that evil doers will be punished pervades many typical Western cowboy films that end up with the criminals under police custody. An important lesson that viewers may draw from such films is that criminals cannot escape punishment.

Furthermore, ideas of chance or probability are taught in senior classes in secondary schools, primary school children cannot be expected to use them in their thinking. Hence the question that associates cutting ones foot and stealing may have been unfair to young children. Young children may in fact have been taught in Sunday school classes that when they do bad things other bad things will happen to them. Kimble's finding of no difference between school going and non-school going children in this question is, because the reasons presented above, not surprising.

As indicated previously, science learning gained ground in Africa as pre-training for science related jobs. What was learnt in science classes was not thought of, among

Africans, in terms of changing one's outlook in life but in terms of learning knowledge and skills that would be useful in future when training for a science oriented job. DeWitt (1969, p. 127) makes a similar observation:

> It appears to me that in the African setting, science education is conceived in very narrow terms, almost exclusively as a technical tool for training a limited number of specialists, science education as an individual value and an end in itself is occasionally talked about, but there is very little in African educational practice that aids the development of an internalised scientific outlook, universal scepticism, and empiricism.

According to the excerpt above the aim of science education in African countries was to prepare students for training in science related profession and not to change their outlook in life. DeWitt's (1969) observation is relevant to Kimble's (1968) study because the 1966 primary school science syllabus, which attempted to change students' outlook had been in use for only two years when Kimble carried out his study. The students he tested were products of the 1961 syllabus. As previously indicated, however, the 1966 syllabus was withdrawn in 1972 and a new syllabus based on the 1961 syllabus was introduced in 1982. The conditions that brought about the situation of no difference in conceptual development between school going and non-school going children in Kimble's study were hence reinstated rather than removed in the 1982 syllabus.

There is, however, no reason for the failure of school going children to perform at a higher level than non-school going children in questions concerning electric circuits and balancing of levers because these were taught in the schools. This failure suggests that the school going children were not learning effectively about these topics. The importance of this study is that it alerted scholars and teachers to the possibility that the scientific knowledge that was being taught in schools in the country could be inert knowledge to the students. Inert knowledge is knowledge that cannot be used (Bereiter and Scardamalia, 1985). To this study, Kimble's (1968) study suggests that some of the conclusions of earlier studies may not be correct because the studies failed to take into account other influences that affect children's thinking about events. The problem of inert knowledge has manifested itself over the yeas as one of poor performance in science. Mbano's (2003) study of cognitive acceleration that is reviewed next was undertaken to investigate this problem.

In 1994 twenty-seven percent of all the registered candidates for MSCE Physical Science absconded from the examination (Mbano, 2003). Poor performance in science had by that time already transformed into fear of failing science among students in Malawi. The question is: why do such highly selected think that they cannot succeed in physical science examinations? Although the problem of poor performance in science is experienced in many developing countries (Odhiambo, 1972; Lewin, 1993; Ogunniyi, 1996; Caillods *et al*., 1996; Dzama and Osborne, 1999), its magnitude in Malawi, as previously indicated, is alarming. In view of the persistent poor performance of students in national examinations, Mbano conducted an intervention study to determine whether teaching the students a series of thinking skills would improve their performance in physical science in national examinations (Mbano, 2003). Mbano used a quasi experimental design with control and experimental schools. A total of 425 students (148 girls and 277 boys) participated in the study. Teaching and learning materials developed by the Cognitive Acceleration through Science Education (CASE) Programme in the United Kingdom (UK), were used to teach students in experimental schools one CASE lesson a fortnight in lieu of their normal lesson for 2 years. Students in control schools continued with their normal lessons undisturbed. Teachers in the experimental schools attended eight training workshops during the 3 years duration of the study. The teachers were also supplied with CASE teaching and learning materials. These materials included teachers' guides, technician guides, students' worksheets and work cards (Adey, Shayer and Yates 1989). Members of the research team visited each experimental school at least two times in a year. No materials were supplied to the control schools and visits to them were limited to pre-testing and post-testing occasions. Pre-test and post-test scores were taken for both categories of schools. The MSCE examination results for biology, physical science, mathematics and English for the students in the experimental and control schools were also obtained.

The results were rather disappointing. Most of the correlations between age and the five other variables including pre-test and post-test on science reasoning tasks and the MSCE examination grades in the four subjects were small ranging from -0.1 to -0.4. The other correlations were all positive ranging from 0.1 to 0.5. From her results Mbano (2003, p. 81) felt that the results indicated that cognitive ability was "not as important as other factors in predicting girls' performance". Commenting on her results Mbano (2003) writes:

> Since girls, who are younger than boys in secondary school classes in Malawi, do more poorly than boys and older boys do more poorly than younger boys on national examinations, it would seem to suggest that there is a gender and age interaction on academic achievement in Malawi. The explanation of this age and gender interaction is unlikely to be related to differences in cognitive development levels. Since the correlations between the performance, on science reasoning tasks are low for most groups except the experimental boys, it would seem factors other than reasoning ability may be critical in explaining the variations in academic achievement. One possible candidate is pupils' learning approach (p. 85).

In the excerpt above, it is presented that the low correlations found between science reasoning tasks and examination scores of various subjects suggest that reasoning ability or cognitive development level is not a critical factor in determining achievement of students in Malawi. It is further suggested that students' approach to learning may be the critical factor accounting for much of the variation in students' achievement. The suggestion that students' approach to learning may be the critical factor in determining achievement is widely supported in the literature (Fairbrother, 2000; Dart, Burnett, Purdie, Boulton-Lewis, Campbell and Smith, 2000; Weinstein and Mayer, 1986). Mintzes and Wandersee (1997) suggest, in this connection, that research in science education should focus on students' learning rather than teaching. According to the authors, efforts to improve science teaching are rapidly approaching a point of diminishing returns and studies should concentrate more on the learning side of the teaching-learning equation (Mintzes and Wandersee, 1997).

Mbano's (2003) study can be criticised for failing to include, at the design stage, measures for controlling possible Hawthorne effects. The observed improvement in the performance of the younger boys may be due to the fact that the students and teachers in the experimental group were being given additional experiences and materials. Similar parallel experiences should have been given to the control students as well. The control group could for instance be given special lessons on the content they were learning with teachers' guides and students' worksheets produced by the research team. Workshops similar to those organised for teachers of the experimental groups but dealing with the teaching of science content should have been planned for the control teachers to offset possible Hawthorn effects. In spite the foregoing criticism, Mbano's (2003) study is a valuable addition to studies of poor performance in science. In so far as building the argument of this thesis is concerned, Mbano's (2003) study provides the following insights:

- Within the schools in Malawi there are groups of students that perform more poorly in science than other groups
- Students' approach to learning may be the critical factor in their achievement
- Girls perform more poorly in science examinations and in science reasoning tasks

Groups of students that perform more poorly than other groups will be referred to as disadvantaged groups. The Problem of poor performance in science is analysed in this thesis from the perspective of disadvantages groups. Disadvantaged groups are hence groups of learners whose performance in science is poorer than that of other groups. In the following, paragraphs performance in science in Africa is reviewed from the perspective of disadvantaged groups.

5. 1. 2 Performance of students in science in other African countries

An abundant and diversified research attests to the existence disadvantaged groups in science education (Ezeife, 2003; Adigwe, 1997; Grayson, 1997; Baker and Taylor, 1995; Mordi, 1993). As Ogunniyi (1986) notes, performance in science in many African countries is generally poor. Compared to their colleagues in Europe or America students in African countries constitute disadvantaged or underachieving groups in as far as science education is concerned. Results of the second IEA confirm that African countries perform poorly in science education as Lewin (1993, p. 11) reports:

> The proportion of schools scoring below the lowest school in the highest scoring country (Hungury) is high in the low-scoring developing countries in the population 2 sample (Ghana 64%, Nigeria 88%, Philippines 87% Zimbabwe 80%). In these countries the performance of the lowest 20% of the students tested indicates that they have learned very little science. This is particularly worrying when it is realized that the Nigerian students were from a higher grade than in other countries, and the Ghanaian students were from selective elite schools. The IEA data suggests that the bottom 20% of the students in Ghana, Italy, Nigeria, the Philippines are scientifically illiterate.

In the excerpt above Lewin explains the performance of African countries in the second IEA study. Population 2 sample were 14 years old students in middle secondary school. As indicated in the excerpt, the performance of African students was very poor. It should be borne in mind that what were compared in the IEA studies are average scores. As indicated in the following paragraphs African scholars have taken on the task of explaining these low average scores.

In his article on developing human capital in Africa, Ogunniyi states factors that bring about poor performance in science in many African countries (Ogunniyi, 1996). Among the factors mentioned by Ogunniyi are government, society, teacher, school, subject matter, examination, family, and student related factors. This study focuses mainly on factors to do with students' learning. Two aspects of learning that form the focus of this study have been cited by Ogunniyi. According to Ogunniyi (1996), students have poor "study habits" and prefer rote learning rather than problem solving (Ogunniyi, 1996, p. 276). Black *et al*. (1998) buttress Ogunniyi's findings about students' preference for rote learning when they report from their extensive survey of education in Uganda that students and early school leavers consider remembering rather than problem solving to be the main trait of science learning. Peacock (1995) sees the problem of learning science in Africa as one of dissonance between concepts of learning embedded in current science curricula and the concept of learning traditionally held by students and their parents. The factors that contribute to failure in students' learning in African countries have further been summarized by Grayson (1996) as:

- Inadequate background in the language of instruction and in mathematics
- Use of inappropriate learning styles
- Behaviours that may have a detrimental effect on their learning
- Absence of prerequisite cognitive skills in the learner
- Lack of practical skills
- Absence of meta-cognitive awareness

In support for the factors listed above, studies have shown that students' fluency in the language of instruction is an important factor in determining achievement (Collison, 1974; Ross and Sutton, 1982; Prophet, 1988; Kulkarni, 1988; Rutherford and Nkopodi, 1990; Rollnick and Rutherford, 1993; Kozulin, 1998; Human-Vogel and Bouwer, 2005). Similarly the importance of mathematical ability in learning science has been widely acknowledged (Derrick and Derrick 2002, Starvy and Tiroshi, 2000; Claxton, 1991; Okpala and Onocha, 1988; Hudson and Liberman, 1982). What appears to be missing from Grayson's list is epistemology of science. A spate of studies has in recent years suggested that students' epistemological beliefs about science and science learning are significantly related to their orientations to science learning and integration of scientific knowledge (Louca, Elby, Hammer and Kagey, 2004; Leach; Tsai, 1998; Songer and Linn, 1991). May and Etkina (2002), writing from the perspective of physics, state in this connection, that students' epistemological beliefs are important because "they influence motivation and affect the selection of learning strategies" (p. 1249).

One representative study in the language mathematical ability and culture categories is reviewed below. Studies about epistemological beliefs and other aspects of learning are reviewed later in the chapter. The studies that are reviewed in this sub section are: Collison (1974); Okpala and Onoch (1988) and, Ehindero (1982). These studies have been selected for in depth review on account of the relevance of the issues they raise to the fore for this study.

The main purpose of Collison's (1974) study was to compare concept attainment of pupils in their vernacular languages and in English a foreign language to the pupils. The study was based on Vygotsky's (1962) thesis that language and thought are closely related and mutually enriching. The science curriculum content at primary school level in Ghana was, at the time of Collison's study, mainly conceptual in character. The curriculum provided learners with opportunities to discuss their experiences and knowledge. The study had two parts: investigation of children's understanding of scientific phenomena and determination of the relationship between language usage and conceptual level attained by individual students. At the beginning of each lesson every child was provided with materials for investigation. Pupils were allowed to work with the materials for 30 minutes. Investigations were followed by round table discussions with the teacher abandoning her or his authoritarian stance. The discussions were audio recorded for detailed analysis. Language usage in English and two vernacular languages Ga and Twi were the main objects of investigation. Four variables namely: number of children's statements; Vygotsky's conceptual levels; the kinds of relationships reported and the mental models constructed were used in assessing language usage. These variables are explained below.

The number of statements made by each pupil was counts of single words, phrases, single sentences or a series of connected sentences made by the pupil during the discussion of the investigations. Meanings of the pupils' utterances were not considered when counting the statements. The number of statements represented the shear "volume" of pupils' participation in the discussions. The counts were averaged across lessons to control for absences.

Vygotsky considers conceptual development to occur in a hierarchy of conceptual structures. In his view oral statements that children make about a concept, fall into one of the four different levels of relationship thinking, depending on the degree of abstraction. The levels of thinking postulated by Vygotsky are: syncretic thinking; complex thinking; pre-conceptual thinking and conceptual thinking. Syncretic thinking is the lowest level of thinking in which linkage between objects or events is based on perception with no regard to logic or function. Statement such as "The electricity can't get through when the wire is heavy" are given by Collison (1974, p. 443) as examples of syncretic statements. In complex thinking initial attempts to explain phenomena are made. As in syncretic thinking, however, perception is the basis for making statements in complex thinking and concrete attributes are used as linkages. The statement "Things sink faster in water than they do in air" Collison (1974, p. 444) is an example of complex thinking. Pre-conceptual thinking is characterized by partial use of abstract linkages in explaining relationships between objects or events. Students begin with abstract concepts, but on further questioning revert to concrete linkages. Pre-conceptual thinking is characterized by such statements as "A falling ball interacts with gravity by falling faster as it comes down" Collison (1974, p. 444). Conceptual thinking is analogous to Piaget's formal operational thought and is the final level of development of thinking in Vygotsky's formulation of development of human thinking.

In examining relationship reported about events, the aim was to determine whether the statements involved perceived or hidden linkages. Statements that compared objects or events with no perceived or tangible links were classified as analogies. Analogies compare things through some kind of mental leap since the similarity exists only in the mind of the speaker. Pupils' explanations that organized the observation into some theoretical structure were coded as models.

Eighty-five pupils drawn from two schools formed the sample of Collison's (1974) study. One school was located in Accra the capital of Ghana while the other school was located in Aburi area. The ages of the pupils ranged from 12 to 14 years. The participants had studied English for six years. The School in Acrra was situated in a Ga-speaking are. The school in Aburi was situated in a Twi-speaking area. Collison the author speaks both Ga and Twi fluently and took both the manipulative and discussion phases of the study. Two teaching units were used in the study. Unit one was about sinking and floating of objects in various liquids and unit two involved pendulums and related concepts. The Accra sample did the first unit in English and the second in vernacular, the Aburi sample, however, did the reverse.

Collison (1974, p. 450) found that the pupils not only contributed more statements in their vernacular languages but also that they tended to "express their thinking more completely, using several sentences". Sentences in the vernacular languages were often more grammatically complex compared with sentences in English. Proportions of pupils making pre-conceptual statements, using external likeness in making comparisons and using analogies were all higher in the vernacular languages than in English. The author concluded that English was a barrier in as far as verbalization of thought is concerned. Ross and Sutton (1982) arrived at a similar conclusion in their study of concept profiles and cultural contexts. These authors set out to identify language barriers that secondary school pupils in England and in the Tiv region in Nigeria experience when learning science. Although their study showed that it was cultural differences rather than language differences that contribute significantly to variation in performance between their samples they acknowledged the inconveniences of learning science in a second language. In their conclusion they write:

> This research set out to see what language barriers there were to the learning of science. In the end, however, it was cultural differences which stand out as more significant than language, though learning in a second language is hardly ideal, particularly when the teaching is not deliberately based on the meaning the learner has developed for himself (Ross and Sutton, 1982, p. 322).

In the excerpt above the authors concur with Collison (1974) about the barrier-effect of English as a language of instruction for science in non English speaking parts of Africa. Other studies that corroborated Collison's (1974) findings are Bamgbose (1984) and Eiselen (2002). It seems that language of instruction is a critical variable in learning science. This study will examine transcripts and written responses to some parts the questionnaire to determine the extent to which language may be a barrier to learning science among students in Malawi.

Okpala and Onocha (1988) sought to determine factors that predict achievement in physics in Nigeria. They used a sample 411 final year secondary school students (252 males and 159 females). The aim was to determine the extent to which selected variables predicted achievement in physics when the variables were taken together. The selected variables were age, gender, home language, word knowledge, interest in physics, study habits, attitude towards physics, mathematical ability, and test anxiety. Four instruments were used to collect data. These instruments were: Inventory of Students' Attitudes to Physics; Study Habits and Test Anxiety Scale; Word Knowledge Test in English; and, Physics Achievement Test. The instruments were developed by the authors and were pre-tested using students in secondary schools. The reliabilities of the instrument were greater than 0.80.

Thirty-eight research assistant assisted the researchers in administering the instruments. The authors used stepwise multiple regression procedure to examine the relationship between achievement in physics as an independent variable and the selected variables as dependent variables. The authors found mathematical ability to be the best predictor of success in learning physics. Mathematical ability was followed by attitudes to physics, word knowledge, study habits, test anxiety, gender and home language in that order. Interest in physics and age were found not contributing significantly to achievement in physics. The authors advise teachers interested in solving the problem of underachievement in physics to encourage development of high ability in mathematics, positive attitudes towards physics, good study habits, good command of written and spoken English and confidence in testing situations. The development of good study habits is premised on students' conceptions of both science and learning. This study sought to determine whether the students in Malawi perceive ability to learn science be something that some students intrinsically have in themselves or as something that develops out of their interaction with teachers and learning materials. This study also sought to determine whether the interview transcripts and the students' responses to the free response items of the questionnaire indicate that the students had problems in expressing themselves in English. Ehindero's study concerns the effects of culture on students' learning and is reviewed in the fillowing paragraphs.

In his study on the effects of eco-cultural factors in operational thought in Nigeria, Ehindero (1982) sought to determine whether or not adolescents who grew up in nomadic and hunting lifestyles would outperform their colleagues who grew up sedentary lifestyles on Piagetian like spatial tasks. He assumed that nomadic hunting lifestyles demand more frequent use of spatial skills while sedentary lifestyles provide for development of formal operational thought. Eighty adolescents (48 boys and 32 girls) participated in the study. The ages of the participants ranged from 15 to 19 years and their mean age was 17.6 years. The subjects were organised into four groups: nomadic schooled, nomadic non-schooled, sedentary schooled and sedentary non-schooled.

Four spatial related tasks and four formal operational tasks were used to assess performance of the various groups of adolescents. A test-retest correlation of 0.94 was obtained on the spatial tasks. Ehindero's thesis that nomadic groups would outperform sedentary groups in spatial tasks and sedentary groups would outperform nomadic groups in formal operational tasks was confirmed. The highest mean score on spatial tasks was achieved by the nomadic schooled and was 9.32. In the formal operational tasks, however, the highest mean score was 16.82 and was achieved by the schooled non-nomadic group. Although the size of experimental groups in Ehindero's study was too small to warrant sustainable conclusions, the study, nevertheless, does suggest that performance on tasks may arise from the experiences that children have had.

Studies pertaining to the other factors mentioned by Grayson (1996) and epistemological beliefs about scientific knowledge and learning constitute the foci of this review and are presented later. A study of disadvantaged students done in South Africa with first year university students is reviewed next and is followed by reviews that point to underachievement in science due to situations in which students find or have found themselves.

Wood and Olivier (2004) have suggested other characteristics of disadvantaged students other than those presented by Grayson (1996). These authors refer to disadvantaged students as under-prepared students. According to Wood and Olivier (2004), under-prepared students bear the following characteristics:

- Lack of work ethic
- Inability to manage time
- Failure in taking responsibility for own action

- Inability to work persistently on a problem
- Underdeveloped critical thinking skills
- Lack of reading culture
- A generally low of literacy

Wood and Olivier based their approach to student development on Bandura's theory of self-efficacy (Bandura, 1977, 1997). These authors consider their approach to be holistic although it is based one theory, the self-efficacy theory. Similarly Grayson's approach is based on learning theories in science education and seems to be oblivious of psychological and sociological aspects of student under-development. To Grayson (1996, 1997), the solution to the problem of student underdevelopment is to present both science content and learning skills to the under-developed students. Wood and Olivier (2004), on the hand, take raising the self-efficacy of the students to be the solution of the problem. It can be concluded that both psychological and learning theory related factors are important in raising the quality of underdeveloped students. Approaches to the problem that take into account many sets of factors are likely to be more successful than those that are centred on one set of factors to the exclusion of other factors. Other authors such as Mordi (1993) and Adigwe (1997) have brought to the fore other variables that need to be considered when addressing the issue of underachievement in science education. Their works are reviewed in the following paragraphs.

Mordi (1993) and Adigwe (1997) introduced another dimension to the problem of poor performance in science. Mordi administered the tests of The Second International Science Study (SISS) and re-analysed them. The SISS was carried out in Nigeria in 1984. Mordi's secondary collection and analysis of the SISS data for Nigeria was partly aimed at finding out whether there were significant differences in the performance students from different cultural zones within Nigeria. Mordi stratified Nigeria into five cultural zones using socio-political, historical, linguistic, religious and geographical factors. He administered the tests to Grade 6 students in primary schools and secondary class 4 students in secondary schools. He employed one way analysis of variance to compare the means of the five zones. The size of his sample for primary school students was 2152 and for secondary school students was 2275. He found significant mean differences in the performance of students from the different cultural zones at both primary and secondary level. Thus within a country there were significant variations in the performance of students from different cultural backgrounds.

Mordi's (1993) findings of variation in performance in science within Nigeria is supported by Adigwe's (1997) study of ethnicity, test anxiety and science achievement in Nigeria. Using three samples of 100 students each (50 boys and 50 girls) drawn from three ethnic groups- Ibibio, Yoruba and Tiv, Adigwe sought to find out if there were significant ethnic and gender differences in test anxiety and achievement. He used a modified version of a standard instrument *Test Anxiety Scale for Adolescents* (TASA) devised by Schmitt and Crocker cited in Adigwe (1997). One of the items for example was "The harder I work on a test, the more I get confused" (Adigwe, 1997, p. 774). Students were asked to indicate whether the statement was true or false for them. He also used an integrated science multiple choice test constructed by himself to test students' grasp of science content. The items of the multiple-choice test were based on science curricula in Nigeria. He analysed his data in two stages. First, a two way factorial analysis with integrated science test score as the dependent variable and ethnicity and gender as dependent variables. He then used a three way factorial analysis with integrated test score as the dependent variable and ethnicity, gender and test anxiety as independent variables. His results confirm the existence of ethnic and gender based differences in performance in science and in test anxiety. The lesson to be derived from these two studies is that within countries there may be some ethnic groups that appear, in terms of performance in science, to be more disadvantaged than others.

The response of African governments to the problem of ethnic variations in students' performance has been to allocate students to schools on the basis of a quota system whereby places are allocated to states or districts or regions. Students from the disadvantaged or low scoring regions or districts are allowed to advance to the next stage in their education even if their scores are below admission levels (Mordi, 1993; Dei, 2004). Hence, the problem has remained unchallenged. Twoli and Power (1989) sought to include the teacher and school variables in determining students' achievement and attitudes to science. Their work is reviewed next.

In their study of influences on science achievement in Kenya, Twoli and Power (1989) sought to assess the importance of selected student, teacher and school characteristics on student achievement and attitudes to science. Among the variables that were the foci of Twoli and Power's (1989) study are school variables. School variables have been considered important aspects of performance of students in developing countries since the re-analysis of the International Education Assessment (IEA) data indicated that, a much larger proportion of the variance is explained by them in developing countries (Heyneman and Loxley, 1982). An earlier study conducted in Uganda by Heyneman arrived at a similar conclusion (Heyneman, 1976). More evidence of the importance of school variables has come from a comparative study conducted by Theisen, Achola and Boakari in which they concluded that "school resources tend to account for more variance in less industrialized" (Theisen, Achola and Boakari, 1983, p. 49). The mission of Twoli and Power's study was to determine the ways in which "cultural, educational and societal forces in a developing country operate and influence science achievement" (Twoli and Power, 1989, p. 204).

Final grade 'O' level secondary education students were the participants in Twoli and Power's study. Four hundred and twenty-four students (215 boys and 209 girls) formed the students' sample for the study. In addition to the 424 students, 24 schools (14 girls' schools and 10 boys' school) and 144 science teachers participated in the study. Sampling of schools was stratified with respect geographical location and school type. Students were clustered within their schools. Several instruments were used to collect data. Forty multiple choice items selected from the IEA study test, on the criterion of relevance to the Kenyan 'O' level syllabus and three structured essay type questions were used to assess achievement of students. Other questionnaires were used to determine attitudes, aspirations and science experiences of the students. Additional questionnaires were used to measure teachers' variables including teachers experience, teacher expectations, professional training and gender.

Twoli and Power (1989) used multiple linear regression analysis to examine their results. The assumptions underlying parametric statistical analysis were tested prior to undertaking regression analysis. Their results indicate that in developing countries like Kenya, school and teacher variables "are very important in accounting for student learning outcomes" (Twoli and Power, 1989, p. 209). Although the sampling of schools was stratified in accordance with geographical location, the authors do not report their findings on the effect of geographical location on achievement or attitude to science.

The point of interest in school variables in this study is whether, from the point of view of students' responses to questionnaire to items concerning self-efficacy, the school effects are evident.

The foregoing review has suggested the problem of poor performance in science is a problem of disadvantaged or under-prepared students. Characteristics of disadvantaged students have been delineated. As Greenfield (1996) cautions, however, these characteristics may be more of the symptoms of the disease, as it were, rather than its causes. Attempts have been made to improve the performance of disadvantaged group. Studies of performance in science of disadvantaged students in other continents other than Africa are reviewed in the following section.

5.2 Poor performance in science in other continents other than Africa

The problem of poor performance in science is not peculiar to Africa. It has occurred in many countries. Whereas in Africa, the problem affects the majority of citizens, in other continents it affects certain minority ethnic groups and women of all races. In the United States of America (USA) for instance, African-Americans, Hispanics, Native Americans are some of the low-achieving ethnic groups (Maple and Stage, 1991; Bacharach, Baumeister and Furr, 2003; Ezeife, 2003; Lee, 2003; Sutherland, 2005). In New Zealand the Maori, who are the indigenous people of the country, are low achievers in science and mathematics (McKinley, Waiti and Bell, 1992). A significant body of research in this area exists and suggests that performance in science depends largely on "prior experiences and construction of new knowledge is based on prior knowledge" (Lee, Fradd and Sutman, 1995, p. 810). The review presented in this section teases out factors that affect the performance of minority and female students adversely. Among the factors affecting performance of minorities and female students in science presented in this part of the review are: low academic functioning; prior knowledge and experiences; language; kind of minority group; and gender. Representative studies pertaining to these factors are reviewed in the rest of this section. Studies concerning students' conceptions of science and science learning are of central interest to this study and are review in the last section of this chapter.

5.2.1 Low academic functioning

From his study of Ethiopian Jews who had migrated to Israel, Kozulin (1998) notes that learning problems of minority students may be brought about by their lack of appropriate language and mathematical skills and, lack of mediated learning experiences (MLE). In mentioning MLE, Kozulin is borrowing a leaf from Feuerstein's theory of structural cognitive modifiability (Feuerstein, Hoffman, Rand, Jensen, Tzuriel and Hoffman (1986). The central assumption of the theory of cognitive modifiability is that the cognitive functioning of any individual is linked to the quantity and quality of MLE that he or she has received (Feuerstein *et al*., 1986, p. 50). These authors argue that such factors as cultural difference, low socioeconomic status and poverty affect students' performance in learning only when they are coupled with lack of MLE. In their view, lack of MLE in an individual, amounts to cultural deprivation of that individual. Culturally deprived individuals have deficient cognitive functions because of their inadequate and insufficient MLE (Feuerstein *et al*. (1986). Deficient cognitive functions can, however, be corrected through specially designed programs called instrumental enrichment (IE). Instrumental enrichment is a substitute for MLE in as far as it enhances the individual's ability to benefit from learning opportunities in formal and informal situations (Feuerstein *et al*., 1986).

The emigration of Ethiopian Jews to Israel created for Kozulin an ideal opportunity to test the efficacy of IE in improving cognitive functioning of students who lacked MLE in their childhood. Kozulin (1998) notes three important aspects of the situation of the Ethiopian Jews. First, there was lack of compatibility between the immigrants' learning practices and the Israeli educational approach to teaching Hebrew as a second language. The Israeli system of teaching Hebrew as a second language assumes that the immigrants are already literate in their mother tongue. The majority of the Ethiopian immigrants were, however, illiterate in their native language. Second, the Ethiopian language was not based on literary texts but on "meanings the transmission of which hinges on the preservation of specific social practices" (Kozulin, 1998, p. 108). Traditional Ethiopian learning is based on apprenticeship, imitation and memorization. Little emphasis is placed on students' own initiative, activity or problem solving in the traditional culture of the Ethiopian Jews. Cole cited in Kozulin (1998) observed in this connection, that much of the learning that occurs in education in most African countries cannot be characterized as "problem solving in the usual sense, and it is possible that learning in African countries is actually retarded by incoherent and rigid instruction" (p. 107). Kozulin (1998) set out to determine whether a program of IE would offset the deficiencies in the education that the Ethiopian Jews have had.

Fifteen girls from Ethiopia who were studying in a boarding school in Israel constituted the subjects of Kozulin's study. Participants' assessment of cognitive change was done through comparison of pre-test and post-test scores in Raven's Standard Progressive Matrices (RSPM). The participants were pre-tested in November 1993 and post-tested in March 1995 on completion of the IE intervention program. Participants received 4 hours a week of IE for a total of 220 hours. The IE materials covered during the intervention were: organization of dots; orientation in space; analytic perceptions; comparisons and illustrations. Bridging exercises that link principles learned in IE lessons with tasks of content lessons and everyday life experiences were also included in the intervention.

Dramatic and significant improvement in the performance of the participants was observed. The average score of the immigrants changed from 29.20 in the pre-test to 43.67 in the post-test. The post-test score approximated to the average Israeli norm of 45.46. The score of a non-IE control group was 29.3. The standard deviations of the pre-test, post-test and Israeli norm were 9.43, 9.06 and 8.25, respectively.

Other intervention programs that have succeeded in improving the cognitive functioning of students are: de Bono's Cognitive Research Trust Programme for teaching thinking (de Bono, 1976) and the Cognitive Acceleration through Science Education Project (Adey and Shayer, 1994; Adey, 1995; Adey, Shayer and Yates, 2001). The latter program has been used successfully in improving cognitive functioning of students in Malawi (Mbano, 2001). Students' lack of mediated learning experiences can be offset through use of intervention programs such as IE and CASE.

5.2.2 Prior knowledge and experiences

The importance of prior knowledge in learning science has been widely acknowledged since 1968 when Ausubel indicated that the most important step in teaching was to ascertain what the students knew about the subject and to teach them accordingly (Ausubel, Novak and Hanesian, 1978). The conceptual change approach to teaching science gives explicit recognition to the importance of prior knowledge in science education (Duit and Treagust, 2003; Linder, 1993; Strike and Posner, 1982; Posner, Strike, Hewson and Hertzog, 1982). The importance of prior experiences has been investigated in Lundin and Lindahl (2005). Prior knowledge and experiences, however, depend on the culture in which a particular child grows. Serpell (1993) defines culture as the forces that impinge on the behaviour of a developing child. Such forces are in Serpell's view, mediated by the child's mental processes and the accumulated resources such as language, theories and technology that exist in the social group in which the child grows up (Serpell, 1993, p. 24). When culture is so broadly defined, there is little doubt about its effects on students' learning and achievement in science education. Ehindero (1982), Finley (1985), Krugly-Smolska (1995) and Lundin and Lindahl (2005) have reported studies that demonstrate the importance of prior knowledge and experiences in science learning. These studies are reviewed in the rest of this section except for Ehindero's study which has already been reviewed.

Finley (1985) argued that if prior knowledge were as important as the science education literature portrays it to be, then variation in prior knowledge would have important consequences for science learning. In his study of variations in prior knowledge Finley (1985) set out to determine:

- Propositions that all students share with respect to a given topic
- Different groups of students whose members share distinctive sets of propositions
- The extent to which students' knowledge of a subject was idiosyncratic

For his study Finley (1985) selected a high school that offered the narrowest range in socio-economic background. The socio-economic background of students in the chosen school was middle class. Finley seems to have confined the socio-economic background of the students to middle to avoid variation in prior knowledge due different backgrounds. The selected high school was located in a Midwestern city in the USA. In the chosen high school, physics lessons on thermodynamics taught by an experienced teacher were selected for close investigation. Thirty-five students drawn from five of the eight grade eleven classes in the school participated in the study. Four students, however, withdrew from the study for various reasons. The interview about instances technique (Osborne and Gilbert, 1980) was used to determine students' prior knowledge. Students were further asked to elaborate and clarify aspects of their observations and explanations. The interviews were tape recorded and transcribed. Each student's statement was broken down into three parts namely: object; predicate and predicate argument. Frequency of students using a particular proposition was tabulated and used to identify propositions used by more than 90% of the students. These propositions were taken to be common to all students while propositions used by 10% of the students were considered to be idiosyncratic. Cluster analysis was used to sort students into groups such that the degree of association was high among members of the same group and low between members of different groups. Similarity of students' descriptions and explanations was used in assigning propositions to clusters

The total number of propositions used by the students was 359. The average number of propositions used by each student was 39.06 and the standard deviation in the number of propositions used by each student was 9.49. Seventeen propositions were used by more than 90% of the students. The propositions that qualified as common knowledge were mainly descriptions of phenomena and prediction about the behaviour of materials in given situations. Seven clusters of statements with an average of 13.50 statements per group and a standard deviation of 7.85 were realised.

Each student used an average of 11.41 idiosyncratic propositions. The standard deviation in the number of idiosyncratic propositions used by each student was 6.52. The importance of Finley's (1985) study lies in his finding of variations in prior knowledge and a number of idiosyncratic propositions, in spite the common socio-economic background of the of the students. Finley (1985) calls for studies to identify the commonalities and variations in students' prior knowledge in important content domains.

In her study of cultural influences in science education Krugly-Smolska (1995) extended Finley (1985) study through adoption of a multicultural perspective. Using an anthropological theoretical framework that considers the transmission of culture to be an important role of education, Krugly-Smolska (1995) set out to determine: aspects of the general culture transmitted; the cultural capital necessary for learning to occur and, differences in interaction and achievement of students from different ethnic backgrounds.

Three grade 9 science classrooms of a large urban school board participated in the study. The participating schools were chosen on the basis of their multicultural populations and willingness of the teachers to take part in the study. Grade 9 was chosen because it is a transition year and all the three sciences chemistry, physics and biology are taken by all the students in that year. The three classes were identified by their initials A, B and W. Classroom A and B were for students who aspired to go to university. These classes were taught by female teachers. Classroom C provided access to a community college or work and was taught by a male teacher. In classroom A, seven students were Canadian while 9 were from a variety of ethnic backgrounds. Nine students in classroom B were Canadian, 12 were Chinese and 14 belonged to other ethnic groups. In classroom W, 11 students were Canadian and seven students belonged to various ethnic and racial groups.

Observations, interviews, field notes and examination of records were the methods used in collecting data. Classroom marks were used to determine the achievement of the students. Both hypothetico-deductive and inductive approaches were used in analysing data. Krugly-Smolska (1995) found that transmission of scientific culture was limited to transmission of accumulated knowledge, skills and modes of communication. Nature of science, in particular, was not communicated to the students. She also found little if any multicultural awareness among the teachers. In performance, she found that Chinese and East Indian students achieved the highest grades and were closely followed by students from the USA, Britain and the West Indian students. Canadian students achieved lower grades compared to students from other ethnic backgrounds. Differences in prior knowledge, knowledge of general culture and communicative competence (cultural capital) that were hypothesized at the beginning of the study were not observed. Krugly-Smolska argues that co-operation and attentiveness among the students from non Caucasian backgrounds may have compensated for any language deficiencies and lack of cultural capital that the students may have suffered from. As indicated later, however, Ogbu (1992) offers a different explanation for successful performance of certain minorities in the developed countries. The importance of Krugly-Smolska's (1995) study is that it demonstrates variation in performance in science education with respect to culture. The study reviewed next is about the role of prior experiences in science education.

In their study of experiences and their role in science education Lundin and Lindahl (2005) sought to determine the role that students' previous experience, originating for example in everyday contexts, may play in the construction of scientific knowledge in a science lesson. The authors further aimed at determining the impact of different classroom agendas on previous experiences. Since one's previous experiences are always changing in response to new experiences, the authors following Ostman cited in Lundin and Lindahl (2005) refer to prior experiences as re-actualized experiences.

Complementary data was collected from a physics lesson in two Swedish schools. In one school grade five to six students participated in the study. In the other school grade 7 students were selected for participation in the study. Schools were chosen on account of their willingness to participate in the study. Data from one school consisted of field notes and official school documents such as students' records, lesson plans and textbooks. Video recordings of lessons were made at the other school. The recordings were transcribed and translated from Swedish to English. The transcriptions were repeatedly studied until re-actualized experiences of students that were embedded in them were identified. Students' utterances involving re-actualized experiences were studied further to determine the role of these experiences in communication and science learning.

The authors found that re-actualized experiences acted like a foundation for understanding science. Textbook writers and teachers make extensive use of re-actualized experiences. The authors illustrate their findings with excerpts from student-teacher discussions during science lessons. They argue that re-actualized experiences make students' participation in class discussion possible. Admittedly, it is hard to imagine how a student with no prior experiences could participate in a classroom discussion. The point that the authors make is that students' prior experience (re-actualized experiences) play important roles in science learning and teaching. The next section reviews studies about the importance of language skills in science learning.

5.2.3 Language skills

The importance of language skills has been widely acclaimed in the science education literature. Lemke (1990) for instance, maintains that language is not only vocabulary and grammar. It is also a system of resources for making meaning. To Claxton (1991, p. 94) language does not only facilitates internal and external communication but it also provides the soil "within which reason and logic can take hold". Lyle and Robinson (2002, p. 18) agree with Lemke (1990) when they define language as means by which human beings assign meanings to their experiences. Crombie (1994, p. 11) concurs with Lemke (1990) but broadens the concept of language to include "a conception of the perceiver, knower and their objects, an apprehension of existence in space and time, a set of assumptions of what exists or seems to exist behind experiences". In Crombie's view language goes beyond the objects or symbols to what lies behind them. Bussmann (1996, p. 253) emphasizes communication in addition to "fixing and transmission of knowledge and experience" as aspects of language. Language can be considered to be a vehicle for communicating, conceptualising and fixing experience and knowledge.

Reviews of studies about the importance of language skills among linguistically diverse students are presented in Lee (2003) and Watson and Houtz (2002). Empirical studies reported by Lai, Lucas and Burke (1995), Lee, Fradd and Sutman (1995) and Tobin and McRobbie (1996) are reviewed seriatim in this section.

Lai *et al*. (1995) set out to understand the cognitive processes that Chinese immigrants in two Australian secondary schools used during early stages of learning science in English as a second language. Their research question was twofold: do the immigrant students recognise science concept labels in the junior science curriculum better in Chinese or in English, and in which language do the students demonstrate better comprehension of science?

The subjects of the study were 23 students who had emigrated from Taiwan between 8 and 25 months before commencement of the study. The students were drawn from two secondary schools in Brisbane. All the students were in mainstream junior secondary science classes. English second language (ESL) support teachers in the schools selected the participants in the study based on their knowledge of the students. The ESL support teachers also granted the researchers, permission to interview the students.

A pilot study of 18 concepts resulted in the selection of 12 concepts that were included in the final interview protocol for the study. The selected concepts were: digestion; absorption; respiration; reproduction; kidney; heart; stomach; proteins; fats; oxygen; carbon dioxide and cell. The protocol was written in English and translated into Chinese. Interviews were conducted in Chinese and in English later. Subjects were first asked to define the concept before answering probing questions concerning the concept. In the case of oxygen for instance subjects were asked to state what the word oxygen meant to them before being asked to name the processes that require or produce oxygen. Subjects were also asked to indicate what would happen to human beings if oxygen were not available to them. Subjects' responses were graded separately in both English and Chinese. A recognition score of "1" was awarded for a spontaneous response that was relevant even if it was conceptually wrong. Subjects who did not respond to a question or gave an irrelevant response were awarded a score of "0". Similarly subjects who responded to a question after being given the Chinese translation of the label were also awarded a score of "0". A comprehension score ranging from "0" to "4" was awarded for each student's understanding of each concept. A score of "0" signified absence of understanding or serious misunderstanding of the concept. A score of "4" reflected understanding beyond that expected of junior high school students.

The authors found that recognition scores in Chinese were higher that in English for all concepts, at all ages of students and for all lengths of residence periods in Australia. Recognition scores increased with increasing age and decreased slightly with increase in time of stay in Australia. Older students were more successful in recognising the concept labels than younger ones. Similarly the comprehension scores in Chinese were higher than in English at all ages and for all periods of residence in Australia. In addition, the comprehension scores in both languages improved with age and declined slightly with increase in time of residence in Australia.

The authors observed that the students formulated their responses to English version questions by translating their responses from Chinese. To the authors, the superiority of students' Chinese is an indication of its importance in students' thinking. In spite of their awareness of the incompatibility of ethnic languages with the scientific language, the authors recommend use of mother-tongue labels of concepts before presenting English language equivalents. Where students in one class speak different first languages, as is the case in many African countries, it is difficult to implement the authors' recommendation. Many languages need to be developed if they are to serve as vehicles for communicating scientific knowledge. The study, nevertheless, makes a significant contribution to knowledge through demonstrating the superiority of the mother-tongue in science learning among ESL students. These results corroborate those of Lee *et al*. (1995) who investigated science knowledge and cognitive strategy use among four ethno-linguistically diverse fourth- grade students. Lee et al.'s (1995) is reviewed next.

Lee *et al*. (1995) conducted their study in two elementary schools in the Southeast of USA. The schools were chosen on the basis of availability of culturally and linguistically diverse students in them. The groups of students who participated in the study comprised of: (a) monolingual English speaking students; (b) African-American students who spoke Standard English and Black vernacular English; (c) bilingual Hispanic students and, (d) bilingual Haitian students. Selected students had to belong to one of the groups and were required to obtain a written permission from their parents to participate in the study. The study was done in controlled environments outside classroom contexts. The Hispanic and Haitian students were further divided into two categories: students who were proficient in English and students who were still in the process of learning English as a second language. Language proficiency was determined by the authors through a story telling exercise using pictures from a wordless book. Only those students whose age was considered to be appropriate to their reading level participated in the study. A total of thirty-two students participated in the students. The students were organised into 16 groups of two students each. The authors refer to these groups of two students as dyads. The dyads were encouraged to work co-operatively rather than competitively.

Six of the eight participating teachers had participated in graduate level training in English to speakers of other languages (ESOL) and had experience in eliciting and analysing language samples. The remaining two teachers also had graduate training in education and showed interest and commitment in working with linguistically diverse students. The teachers represented the four ethno-linguistic groups and two gender groups.

Students were asked to work on three tasks namely: hurricane and tornado; lever; and, sinking and floating. The tasks involved finding out, manipulating, generalising and summarising ideas concerning the topics. The students worked in dyads of students with the same language and culture with teachers from the same cultural background and gender. Each science task was accompanied with an elicitation protocol to ensure consistency among teachers. Teachers were encouraged to change to the students' alternative languages whenever necessary. All sessions were audio- and videotaped and audio recordings were transcribed and analyzed. The video recordings were used to observe and analyze non verbal behaviour. Data analysis employed both quantitative and qualitative methods. A coding system for analyzing students' science knowledge, vocabulary and strategy use was developed and used in the study. Total scores for knowledge of science, vocabulary and strategy use were obtained for each dyad. The frequency of strategy use for each dyad was also determined.

The results about science knowledge and vocabulary indicate wide variations among the dyads of students. With a possible maximum score of 42 for the three tasks, the scores for the dyads ranged from 32 to 3. The mean score for the 16 dyads was 15.6 and the standard deviation was 7.5. The study showed that students who thorough grasp of science knowledge and vocabulary outperformed those who had problems in either science knowledge or vocabulary or both. The authors found students who appeared to understand the vocabulary but did not actually understand what the terms meant. These results corroborated those of Collinson (1974, p. 455) who in a study of concept formation in Ghana, reviewed previously, concluded that when children are taught in a foreign language "they may mimic adult concepts without any appreciable contribution to their conceptual growth"

Similarly, Tobin and McRobbie (1996) sought to find out why there was a high proportion of Chinese students in physics and chemistry classes they were studying in Australia. The authors further investigated factors affecting variation in the performance of Chinese and English speaking Australians. These researchers were puzzled by the fact that some students from Asia were highly successful in their learning of science subjects but in the classes they were studying Chinese students were achieving in science at a lower level than English speaking Australians.

Tobin and McRobbie (1996) used interpretive procedures to focus on the immediate and local meanings perceived by the students and teachers. The authors incorporated an actor oriented as well as a structure oriented view of social phenomena. While the actor oriented view sees the teachers' and students' actions as related to their intentions and capabilities, the structure oriented view considers students' and teachers' actions as functions of their positions in their social settings. Neither of these views is superior to the other both views contribute, according to the authors, to understanding of "what is happening and why it is happening" (Tobin and McRobbie, 1996, p. 268).

The sample of Tobin and McRobbie's (1996) study consisted of 15 grade 11 chemistry students (9 boys and 6 girls) drawn from a government secondary school in Brisbane and their teacher. The study focused on the activities of two students who had migrated from Hong Kong. The researchers visited each chemistry class every day of the week to observe the unit on titrations and electrochemistry. Each lesson was videotaped. The researchers used multiple methods of data collection to increase the likelihood of making confirmable assertions. More data was collected through: field notes; analytic memoranda based on of lessons; interviews with the class teacher; interviews with six students, colleague teachers and administrators. The class teacher was interviewed five times, each for about 1.5 hours. The six students were each interviewed once for one hour. The teacher and the students completed separately a 25-item questionnaire that surveyed their perceptions of their learning environment.

The two students and their teacher wrote separately accounts of what was happening in their class as students got engaged in learning tasks.

The authors found that over representation of Chinese students in science classes was due to their belief that understanding of English was not a necessity for them to succeed in learning sciences. They also found that limitations in "speaking, writing, and understanding English were a disadvantage to most Chinese students" (Tobin and McRobbie, 1996, p. 272). Following Ogbu (1992) the authors take the Chinese students in Australia to be voluntary minorities and their work suggests that even those students who are positively oriented to learn science find difficulties when science is taught to them in a second language. Ogbu's (1992) theory of voluntary and involuntary minorities is presented in the next section.

5.2.4 The kind of minority group to which one belongs

I have chosen to use Ogbu's (1992) theoretical framework when analysing studies on the performance of ethnic groups because it enables me to explain variations in the performance of students from different tribes in Africa better. As Dei (2005) observes, post-colonial education in Africa has perpetuated disparities and inequalities based on ethnicity, language or religion that developed during the colonial era. Students from tribes that resisted colonial education most, continue to perform poorly in school today. Dei (2005) reports that independent Africa has attempted to solve the problem by giving students from the underachieving-tribes preferential treatment when selecting them for higher education. Such preferential treatment has enabled students from underachieving ethnic groups to get places in higher education institutions even if their performance in examinations is below minimum admission requirements. Dei (2005), however, indicates that this practice has led to further marginalisation of the ethnic tribes concerned as it has led students from these minorities to think that they do not need to work hard to be given a place in higher education. Ogbu's (1992) theory provides a plausible explanation of these observations as indicated below.

According to Ogbu (1992) three types of minority status can be identified namely; autonomous, voluntary and involuntary minorities. Autonomous minorities are people who are minorities because the size of their total population in a given country is small. Examples of autonomous minorities in the USA are Jews, Mormons, and the Amish (Ogbu, 1992). Voluntary minorities are people who have moved on their own will to another county because they desire better economic opportunities or greater political or religious freedom. Voluntary minorities experience some initial problems due differences in culture and language, when settling in their new country, but are determined to overcome these problems. Examples of voluntary minorities are Chinese students in Australia (Tobin and McRobbie, 1996) and Punjabi Indians in the USA (Ogbu, 1992). Voluntary minorities try their best to overcome cultural and language boundaries and succeed in their learning.

Involuntary minorities are people who are either original residents of a colonised country or people brought to another country through slavery, conquest or forced labour. These minorities often are confined to menial jobs and are denied or deny themselves opportunities to become assimilated into the mainstream culture. In Ogbu's (1992) analysis, it is the involuntary minority groups that experience greater and persistent problems with school learning. The American Indians and African Americans in the USA are examples of involuntary minorities. Some of the ethnic tribes in Africa were voluntary minorities in as far as they needed the protection of the colonial administrators and missionaries against warring tribes, but other tribes were involuntary minorities and felt inconvenienced by coming of colonial administrators and missionaries to Africa. It is a matter for discussion whether the involuntary minorities in Africa adopted attitudes of voluntary minorities to science learning when African countries became independent. Dei (2005) suggests tribes that were marginalised in the colonial period continue to be marginalised in the post-independence era. This suggests that some tribes in Africa have maintained their involuntary minority-stance to learning well into the post independence era.

Ogbu's (1992) work has been used extensively in interpreting studies on the performance of minority groups in science (Rowe, Vazsonyi and Flanner, 1995; Tobin and McRobbie, 1996; Gallard, Viggiano, Graham, Stewart and Vigliano, 1998; Carbonaro, 2005). In Ogbu's view neither the core curriculum nor multicultural education is likely to succeed in educating minority students because both approaches to minority education ignore "the minority students' own responsibility for their academic performance" (Ogbu, 1992, p. 6). This implies that any innovations of learning that concentrate only on manipulating variables external to the learner to the exclusion variables that are internal to the learner are unlikely to succeed. Carbonaro (2005, p. 44) concurs with Ogbu (1992) when he argues that the practice of placing more emphasis on structure than agency in explaining differences in learning, overlooks "effort" an "important potential resource that students have and can be used to improve their leaning outcomes". He maintains that both structure and agency are important in determining students' achievement. In most innovations of science education in Africa the tendency has been to resist appearing to "blame the victim" to borrow a phrase from Carbonaro (2005, p. 44). This means that the blame for poor performance is solely put on the curriculum, school, teachers or the education system, the students' culture or worldview, and the student herself or himself is considered to contribute nothing to his or her failure. To appreciate Ogbu's (1992) arguments it is necessary at this point to discuss the concept of multicultural education before reviews of studies on performance ethnic minorities are presented.

Multicultural science education

Multicultural science education like many concepts in education is not a unified concept. From its humble beginnings as an idea, a process and an educational reform movement whose aim is to deal with challenges posed by students from ethnic and cultural minorities, multicultural science education has grown into a challenge to universalism in science education (Hodson, 1993; Atwater and Riley, 1993; Matthews, 1994; Atwater, 1996, 1998; Stanley and Brickhouse, 1994, 2000). Multicultural science educationists like Stanley and Brickhouse (2000, p. 40) argue that because of the impossibility of removing the "the observer from an observation" the truth claims of Western science are of equal status to those of indigenous knowledge of other cultures. Assuming that indigenous knowledge of the various ethnic tribes is of equal value and truth status, some multicultural science educationists have condemned the teaching of Western science to ethnic minorities (Cobern, 1994; Aikenhead, 1996; Gaskell, 2003). These authors explain failure of students from minority groups in learning science in terms of indifference of minority students to learning science. Cobern (1994, p. 15) for instance, claims that failure of minority students in science is not due to their lack of ability to understand "what is being taught, it is simply that the concepts are either not credible or not significant". As Matthew (1994, p. 189) states, advocates of multicultural science see "no good cognitive reason to introduce Western science to students in traditional cultures". Sometimes the argument of the multiculturalists in science education approximates to allowing students in Western countries to study science while confining students from other cultures to their ethno-sciences. Matthews (1994, p. 179) for example, observes:

> It is also widely claimed that science education in non-Western cultures needs to be different from that in the West; it needs to be more multicultural if not completely ethno-scientific.

In their paper on multiculturalism and science education, Stanley and Brickhouse (1994, p. 395-396) seem to concur with Matthews in the excerpt above when they write:

> At least in the U. S., Western science is dominant. Failing to provide students with a firm understanding of the Western scientific tradition would unquestionably limit their ability to participate in contemporary scientific discourses. Although we believe U. S. students must become competent in Western scientific discourse, they also need to understand that this is one particular way, among many, of thinking about the natural world.

The authors in the excerpt above justify the teaching of Western science to students in the U. S. They feel that there are countries in which science is not dominant. These are presumably, the countries that have to teach ethno-science only. The authors confirm Matthews (1994) suspicion that they would rather have other cultures teaching ethno-science than Western science. Since the world is progressively becoming one village, it is strange that these authors could see a role for Western science among students in the USA but fail to see similar roles for science for students in other nations.

The implied assumption of the multiculturalists in science education is that if minority students were taught science derived from their culture and environment then they would be successful. It seems that success of students in learning science rather than utility of the knowledge and skills transmitted is the overriding priority of the multiculturalists in science education. Success of students in learning science, however, does not depend on one factor. In independent Africa the pressing question is not what science should we teach? It is how should we teach Western science so that local cultures are not denigrated? Ogunniyi (1988, p. 8) expresses this succinctly:

> The aim of education should not be to supplant or denigrate a traditional culture but to help the people meet modern challenges.

To meet the modern challenges that Ogunniyi refers to in the excerpt above, like students in the USA, students in Africa need Western science. Neither traditional African culture nor Western science provides solutions to modern challenges. Students have to select elements from traditional culture and science to function effectively in the modern world. Teaching ethno-science to the exclusion of Western science is not the policy in science education in many African nations. Studies concerning learning science among minority groups are presented next.

Studies of performance of minority groups

An extensive and growing literature has identified factors associated with performance of minority students in science. The factors are: students' learning styles (Rosenthal, 1995; Richardson and Fergus, 1993); Beliefs or reservations that arise from students' cultural background (Ezeife, 2003; Baker, 1998; Cobern and Aikenhead, 1998; Powell, 1990; Odhiambo, 1972) and school practices (Zuniga, Olson and Winter, 2005; Agholor and Okebukola, 1998). Studies that are reviewed next have been chosen because of they bring to the fore important perspectives on learning that are relevant to the research questions of this study. The chosen studies are: Greenfield (1996); Bacharach *et al*. (2003); Zuniga *et al*. (2005).

In her study of gender, ethnicity science achievement and attitudes, Greenfield set out to find three things: differences in students' achievement associated more with ethnicity than gender; effects of ethnic differences on performance in science between Japanese and Caucasian students, and Filipino and Hawaiian students and, attitudes to science. Except for questions involving perception of ability and levels of achievement in science, attitudes to science are not the focus of this study. Greenfield (1996) used the Standard Achievement Test (SAT) series, eighth edition test scores administered in 1993-1994 academic year to Grades 3, 6, 8, and 10 students in the State of Hawaii in the USA. Her sample for the SAT test comprised of 3677 students (1685 girls and 1992 boys). The sample scripts were collected from different parts of the State of Hawaii so as to represent the four major ethnic groups of in the State. The four major ethnic groups were: Japanese, 623 students (279 girls and 344 boys); Caucasian, 1100 students (557 girls and 543 boys); Filipino, 687 students (340 girls and 347 boys) and Hawaiian or part Hawaiian, 1105 students (529 girls and 576 boys). Data on attitudes to science was collected through an attitude to science survey developed by Simpson and Troost (1982). Greenfield (1996) added two questions to the standard survey. One question aimed at determining students' attributions of success or failure in science education in secondary schools while the other asked students to identify and rank two major reasons for enrolling in advanced science courses. More than a one thousand students drawn from a cluster schools (elementary, intermediate and high school) participated in the survey.

Descriptive statistics, analysis of variance and chi-squared tests were used to analyse the data. Three-way analysis of variance tests were performed on SAT scores and attitude survey data. The SAT scores and the survey data were used as depended variables, respectively, while ethnicity, gender were used as independent variables. To facilitate the analysis, the 10 grade levels were collapsed into 5 levels. Possible interactions between the variables were investigated through analysis of combinations of the independent variables.

Greenfield's (1996) hypotheses that ethnic differences would be greater than gender differences and, that Japanese and Caucasian students would outperform Filipino and Hawaiian students were confirmed. The hypothesis that gender differences would favour girls was, however, rejected. She found that Caucasian students rated their science achievement higher than Japanese students. She also found that perceptions of science and science careers were consistently negative among Hawaiian students and consistently positive among the Japanese. Young students tended to have more positive perceptions of science and science careers than older students. In explaining these results Geenfield (1996, p. 922) argues:

> Students who consistently score in the lower ranges on tests might well develop a negative perception of their own abilities. If they are channelled into lower academic tracks in subjects such as science and mathematics, as occurs in some local schools, they might also develop the impression that being a scientist is out reach for them.

According to the excerpt above consistent failure in examinations or tests in science may lead students to developing negative perceptions of their ability to learn science. The negative perception, in the absence of role models of scientists from the ethnic group concerned, may lead to feelings of fear of failure. Fear of failure in science learning can develop into depressed social and education stnding. The fear that Greenfield (1996) points out is not fear of education it is fear of failing science.

Greenfield's (1996) study falls fittingly into Ogbu's (1992) theoretical framework. The Japanese and Filipino are voluntary minorities. The Caucasians form the main culture to which the Japanese and Filipino would like to be assimilated. The original inhabitants of the island, the Hawaiians are the involuntary minorities. As predicted by Ogbu's (1992) theory, performance of the Hawaiians was poorest.

Greenfield's (1996) finding that ethnic difference in performance in science, are greater than gender difference are corroborated by those of Bacharach *et al*. (2003). These authors used the data of the National Educational Longitudinal Study (NELS) to investigate any changes in the racial academic achievement gap in science from 8th grade through 12th grade in the USA. They used the NELS (1988/1994) data because this was the most recent nationally representative data that was accessible to them. Their participants were children that were enrolled in the NELS: 1988/1994. Sampling procedures were used to obtain a nationally representative sample of 8th grade students from a nationally representative sample of middle schools. The sample size at the beginning of the study in 1988 was 21,000 eighth grade students. In 1994 a postsecondary follow-up was conducted on a sample of 14,915 students of which 13,120 were in the original 1988 sample. It was noted that the percentage of white students (84%) who graduated from secondary school in the cohort was higher than the percentage of Black students (72%). The final sample consisted of 5,463 White and 668 black students. This sample comprised of only those students for whom there was a complete set of data of the following variables: gender; race; and, scores on science achievement tests given during 8th, 10th and 12th grade years.

The Educational Testing Service constructed the achievement test for the NELS: 1988/1994 survey. The science part of the test consisted of 25 items covering topics in life, earth, and physical sciences that were to be done in fixed time. In analysing their data Bacharach *et al*. (2003) used the hierarchical linear modelling (HLM). This involves two levels of analysis. First, estimates of regression coefficients and intercepts for each student are determined. The regression coefficients represent average yearly change in test scores as the student progresses from 8th grade to 12th grade. The intercepts are estimates of 8th grade test scores. Second, the regression coefficients and intercepts are used to estimate the average regression coefficients and intercepts for groups of students. Similar average regression coefficients mean the same rate of improvement in science achievement in the two groups being compared.

The authors found significantly different average 8th grade science achievement test scores. Like other authors cited above, they also found that gender differences were small compared with racial differences. Their results further indicate that the size of the racial achievement gap between White and Black students increases as they progress from grade 8 to grade 12.

In explaining their results the authors cited: poor quality of schools attended by black students; the fact that Black students are less likely than White students to value education; racial stigma that reduces Black students' self-esteem; family factors that favour White students; de facto segregation and academic tracking. The authors argue that many factors account for the poor performance of Black students. These authors feel that "no single study or analysis is likely to provide a definitive answer" to the problem of racial differences in achievement in science Bacharach *et al*. (2003, p. 124).

Among the factors mentioned by both Greenfield (1996) and Bacharach *et al*. (2003) is academic tracking. Zuniga *et al*. (2005) investigated this factor. The purpose of their study was to assess the effectiveness of mechanisms for adaptation of students in science classes in a high school that had just experienced a large immigration of Latino students. The authors sought to find out the effectiveness of the schools' policies in providing access to all students to equitable science education experience.

Morgan Senior High School, the school in which Zuniga *et al*. collected their data is located in the State of Iowa in the USA. In the 1999-2000 academic year the school had 625 students in grades 9-12. The school was chosen for the study because it had a large proportion of immigrant Latinos. The authors' research question was twofold: to what extent were Latino students placed in tracks based on their academic ability and how successful were students in each track as indicated by passing rates and further enrolment in advanced or college preparatory science classes?

Initially, Zuniga *et al*. (2005) selected a sample of 157 students drawn from practical science and earth science classes during 1997-2000 academic years. Practical science is a general science review course intended for learning disabled students. Earth science is a required course for graduation at Morgan High School. All students registered as Asian or non-Latino and learning disabled and medically disabled students were dropped from the sample. Students who had missing data on key variables of the study were also excluded from the study. The authors ended up with a sample of 101 students (70 white and 31 Latino).

Parental permission to access students' records was requested and granted by all parents except 9 who denied the researchers access to students' records. Initial set of data was collected in 2000 and follow up data for students enrolled in any science course was collected in May 2001. The data collected from students' records included student and family characteristics. The independent variable of science track placement was measured by the track in which a student was placed on being enrolled at the school. The two tracks were earth science or practical science. Students who begin in earth science and are unsuccessful are placed in practical science. The unsuccessful students constituted a third track. The earth science track is a traditional science track. The practical science track is usually for students who are considered by the school administration to be not proficient in their use of English. Zuniga *et al*. (2005) used students' cumulative grade point averages (GPA) and freshman Iowa Test for Educational Development (ITED)-Iowa ranked science scores to measure students' academic performance. These two measurements were further used to assess the appropriateness of the school's placement in specific science track. The researchers assumed that students with the highest GPAs and freshman ITED Iowa-ranked science scores would be placed in the earth science track and those with lower scores would be places in the practical science track.

Contingency tables that provided comparison between observed placement and expected placement were used in analysing the data. Analysis of student success was performed using grades that the students achieved in earth science in their first attempt. The authors found that placement of students in tracks "is not statistically independent of a student's ethnicity" (Ziniga *et al*. 2005, p. 390). Expected numbers of students in the earth science in the earth science track, based on both GPAs and freshman ITED-Iowa ranked science scores favoured the White students. It seems that White students were placed in the earth science track and Latino students in the practical science track regardless of their academic performance. These results suggest that the school used misclassification to deny minority students access to science education. Zuniga *et al*.'s (2005) study demonstrates that unwillingness of school management to facilitate success of some groups of students in science can give rise to poor performance among the blocked groups of students. In the next section studies pertaining to effects of gender on students' performance are reviewed.

Differences in performance in science among different ethnic groups cannot be fully explained from a single perspective or paradigm. Factors that affect performance of ethnic groups in science include relationship of a particular ethnic group to the main culture, societal factors, institutional and individual factors. The functioning of these factors depends on the individual circumstances in which a particular ethnic group finds itself. As Ezeife (2003) maintains there is no homogeneity of individuals in ethnic groups. Differences in learning styles and in likes or dislikes about learning are common among students of one ethnic group. "Stereotyping" of minority students should be avoided (Ezeife, 2003, p. 338).

5.2.5 Gender differences in students' performance

In 1981, Alison Kelly used the term "the missing half" to describe low participation of girls in science (Parker, Rennie and Harding, 1995). Today there are countries in which at the secondary school level there is no "missing half". In countries such as France, Korea, Thailand, Jordan and Malaysia girls are equally represented as boys in science classes (Caillods *et al*. 1996, p. 104). Since the1970s research in science education has established some basic facts about gender differences in the performance of girls and boys. Gender differences favouring boys are nonexistent in lower primary school classes but appear in secondary school. The differences tend to be highest among best performing students (Preece, Skinner and Riall, 1999; Lauzon, 2001). Differences in the performance of boys and girls in standardised science tests have been declining with time (Kerr and Kurpius, 2004; Demie, 2001; Parker *et al*. 1995). In comparing performance of boys and girls mean scores have been used. Feingold (1992, p. 74), however, used variability rather than central tendency and found that "males were more variable than females in general knowledge, mechanical reasoning, quantitative ability, spatial visualisation and spelling". This means that although the mean scores of girls were lower in these subjects than that of boys, the girls' scores were more closely batched to the girls' mean score than were the scores of boys to the boys' mean score. Feingold (1992) argues that the decreasing effect sizes of cognitive gender differences that have been reported in the literature, suggests that cognitive difference between the sexes are affected by social factors that have been changing in society.

It has to be remembered, however, that in the 1980s various attempts were made to help secondary schools to find and apply ways of encouraging girls to study physical sciences and crafts (Smail, Whyte and Kelly, 1982). An international conference on Gender Science and Technology (GASAT) was held for the first time, in Eindhoven, in the Netherlands and GASAT conferences became a periodic event in the1980s and early 1990s. To improve participation and performance of girls in science education, it became necessary to set up various projects whose aim was to enable girls to take up the challenge of learning science. Parker, Rennie and Harding (1995, p. 198), describe some of these projects. Factors that account for poor performance of girls in science mentioned by Parker et al. are: girls' prior experiences; the image of science and, the nature science learning environments in schools. It seems that girls' lesser familiarity with technical things is one of the factors that account for their poor performance in science subjects. Similar findings are reported in Steinkamp and Maehr (1984), Sjoberg and Imsen (1988). To gain insights into girls' performance in science from the research literature about gender and science education, four studies have been selected for detailed review. The selected studies are: Catambis (1995); Preece *et al*. (1999); Francis (2000) and Kato and Yoshida (2003).

The purpose of Catsambis's (1995) study was to understand the processes that bring about inequality in the participation of women in science related careers in the USA. She reasoned that knowledge of experiences of male and female students in schools could be used to bring about improvement in the participation of women in the sciences. Data for her study was obtained from the base-year study of the National Educational Longitudinal Study (NELS) of 1988. The NELS-88 sample is a stratified sample of 1,052 schools and 24,500 students (Catsambis, 1995). The students were interviewed in 1988. Data concerning students' socioeconomic status, perceptions of self, school life, educational experiences and future aspirations was collected. A cognitive test battery developed by the Educational Testing Service was also administered to the students. Data about parental support for educational activities was also collected. Teachers' surveys solicited data concerning teachers' perceptions of the sampled students and classroom performances of the students. Five variables investigated in Catsambis (1995) were: science achievement; science interest and attitudes; social background characteristics and science teacher evaluations.

On achievement in science Catsambis (1995) found that gender differences in mean test scores were small but varied with race and ethnicity. The differences were 18%, 11% and 0%, of a standard deviation among Latinos, whites and African-Americans, respectively. Like Zuniga *et al.* (2005), Catsambi's (1995) study found that the practice of placing some students in a high ability classes gives such students an advantage over other students. She found that "white girls gained by not being placed in low-ability classes as often as their male counterparts" Catsambis (1995, p. 249). Students in high-ability classes receive intensive training, are exposed to advanced topics and have ample opportunities to study mathematics and science subject. The important point that Catsambis's (1995) study raises is that since placement of students in high-ability classes depends on such factors as race, gender, socioeconomic status and classroom behaviour rather than demonstrated ability in science, the decision to place any particular student in high-ability or low-ability class is of great significance in students' lives. Such a decision amounts to giving or denying a student the chance to pursue science or science related professions. In case of the situation in Malawi, this means that the criteria used in placing students into high or low-ability classes have to be closely scrutinized, to avoid denying students opportunities to learn science and become scientifically educated persons.

Preece *et al*. (1999) explored gender differences in science achievement in England and Wales at the end of 9th year of schooling. Their data was collected from a large sample of year 9 students that took the national Key Stage 3 science tests in England and Wales in 1966. Preece *et al* (1999) also investigated the relationship between gender gap and the discriminating power of the test items.

The National Curriculum for Science in England and Wales is organised into four attainment targets: experimental and investigative science; life processes and living things; materials and their properties and physical processes (Preece *et al*. 1999). Ten levels of achievement are defined for each attainment target. In 9th year of schooling, students are normally entered for two written tests, covering either, level 3-6 or level 5-7 depending upon the assessments of the schools in which the students are enrolled. Students are allowed one hour to complete each test. Development of tests involves three rounds of pre-testing during which the questions are refined and thresholds are established (Preece *et al*. 1999). The authors report coefficients of correlation between papers of the tests of the order of .8 and greater.

Participating schools in the Preece *et al.* (1999) study were selected from a stratified sample of 664 schools chosen from all regions of England and Wales. Questionnaires on the quality of the tests and the administration arrangements made by the individual schools concerning the tests were sent to these sampled schools. Using the schools' responses to the questionnaires, some 46 schools that were considered as representative of schools in England and Wales were selected for participation in the study. Each participating school supplied the authors with 50 completed science test scripts that were analysed to determine answers to the research questions of their study. The mean scores and standard deviations of male and female students were compared using t-tests of significance between male and female mean scores. The statistic D is the standardized difference in mean scores between males and females on the tests. According to Preece *et al*. (1999) D is calculated by dividing the difference in mean scores between males and females by the average of the male and female standard deviation. The relationship between discriminating power and gender performance differences were investigated through part-total correlations. These correlations were calculated for each part of a question for those students who attempted that part of the question.

The test results indicate that differences between male and female mean scores were negligible in level 3-6 papers and significantly different in level 5-7 papers. Similarly values of D were negligibly small for level 3-6 papers indicating not significant higher means for male students. In the level 5-7 papers, however, values of D indicated small to medium gender effect in favour of male students. Gender differences were found to be more pronounced among the more able students who were entered for level 5-7 papers. The authors found that the largest differences between the performance of male and female students were in physics questions. They also found that more discriminating questions or items in science showed gender differences in favour of males. It seems that although gender differences in mean scores in science have disappeared in some countries among high ability group differences in favour of males are still evident. Preece *et al*. (1999) state in this connection that at the age of 17 years, there are in the USA twice as many males as females in the top 10% of the tests. Equal test or unequal test means in favour of males may overshadow inequalities in the composition of the top 10 % of science students.

In the late 1990s in England sufficient progress had been made in girls' performance in the sciences in to start worrying about boys "underachievement" (Griffin, 2000; Demie, 2001). Similar progress has also been reported in Ontario in Canada where the Education Quality and Accountability Office (EQAO) assessment of 1999-2000 "showed more girls performing at the upper levels in grade 3 and grade 6, the gap being lower among grade 6 students" (Lauzon, 2001. p. 5). The results of the Programme for International Student Assessment (PISA) that were released in 2001 indicated no gender differences in mean scores in mathematics, science and reading among 15 year-olds in all the provinces of Canada. Francis's (2000) study took its point of departure from this very observation that girls have started outperforming boys in mean scores in the science. She wondered whether or not the improvement in the performance of girls in traditionally masculine subjects, reflected any shifts in students' constructions of gender and learning. She wanted to know whether the changing achievement patterns have had any effect at all on students' perceptions of gender and learning.

Francis's (2000) study involved classroom observation and semi-structured interview of 100 students (50 boys and 50 girls) drawn from three different schools in London. The students' ages ranged from 14-16 years. The students were selected in such away that approximately one third were white, one third were Afro-Caribbean and the last third was composed of other ethnic groups. Students were asked what their most favourite and least favourite subjects were and whether or not male and female students have the same ability at different subjects.

Francis (2000) found that both boys and girls rated English as the most popular subject and mathematics as the second most popular subject. More girls listed mathematics as their most popular subject than boys. Science was the fifth most popular subject among girls but the third most popular subject among the boys. Mathematics and science were the first and second least favourite subjects, respectively among the girls while the boys considered French and mathematics to be the first and second least favourite subjects, respectively. These findings imply that although gender differences in performance in science have been eliminated gender differences in attitudes to science have not substantially been changed. This study points to the need to change attitudes of girls to science even in those school environments where girls are already outperforming boys.

Francis's (2000) findings are supported by those of Kato and Yoshida (2003) who, in their study of gender issues in Japan concluded that gender inequality exist in junior high schools in their country. According to the authors Japan used to be a traditional society in which predominance of men over women was a fact of life. Women could not be enrolled in science courses at university level before the First World War. Japanese law of education of 1947, however, gave men and women opportunities to enrol in any field of at any tertiary institution. The authors maintain that although the number of girls who take science major courses is increasing, in magnitude, this number is still very low compared to that of boys. According to the authors 42 percent of male and 48.1 percent of female students entered tertiary education institutions after graduating from high school in 1998. Females, however, constituted only 12 percent of all students enrolled in science and engineering. Kato and Yoshida (2003) sought to investigate gender differences in junior high school science students in Japan. The authors sought to do three things: to find out gender-related ideas that students have about differences in performance of boys and girls in science; to determine the factors that promote differences in the performance of boys and girls and to determine whether students in Japan were loosing interest in science.

Quantitative and qualitative methods were combined in Kato and Yoshida's (2003) study. Pilot surveys and interviews were used to determine the suitability of the instruments and methods used in the study. Two hundred and twenty-two junior high school students consisting of 111 females and 111 males drawn from grades 7, 8 9 and 12 in Aichi prefecture in Japan participated in the study. In addition, 20 science teachers were interviewed about their views on gender differences in the course of the study. Students' ideas about gender differences were solicited through a questionnaire, while those of teachers were collected through interviews. Each teacher was interviewed for approximately 30 minutes. The authors found similarities between students' and teachers' ideas of gender differences. They developed five perspectives for gender disadvantages in junior high school science education in Japan. The perspectives are:

- Students' preparation for science
- Science curriculum
- Science image
- Students' consciousness about gender
- Community gender bias

In explaining their findings the authors claim that boys and girls have different science related experiences outside the school that contribute to the gender gap in their achievement in science.

5.3 Science and science learning

Learning science as the National Research Council (1996, p. 2) stipulates is "something that students do, not something that is done to them". In similar vein, Marton and Booth (1996, p. 539) argue that learning is the "transition from not being able to, to being able to, as a result of doing something, or as a result of something happening". Writing from the perspective of university education McDermott (2001, p. 1134) expressed the roles of students and lecturers in learning succinctly:

> Meaningful learning requires the active mental engagement of the learner. The role of the lecturer is clearly important. He or she is the one who motivates the students and the one to whom they look for guidance about what they need to learn. The lecturer, however, cannot do their thinking for them. The students must do it themselves. Some are reluctant to do so; others do not know how. For most students the study of physics is passive experience.

In the excerpt above, McDermott acknowledges the importance of students' active mental involvement in learning tasks as a condition for the actualization of meaningful learning. Most students, according to the author, are passive learners of physics because of either, their ignorance of the importance of active mental engagement in meaningful learning or their reluctance to learn physics meaningfully. Meaningful learning takes place when a learning task is integrated in a non-arbitrary and substantive manner in the learners' prior knowledge (Ausubel, Novak and Hanesian, 1978). In his study of learning among undergraduate students Perry (1988) drew conclusions that are similar to those of McDermott in the excerpt above. Perry (1988) found that the learning difficulties that students experience spring from their views of knowledge. He also found that the process of schooling may create in students' minds misconceptions about the nature of learning. Perry (1988) studied development of concepts of knowledge by interviewing Harvard undergraduates over their four years of their stay in college. The point made by these authors is that students' ignorance of the nature of meaningful learning or their reluctance to learn things meaningfully is at the core of learning difficulties that they experience in learning science.

The importance of students' knowledge of the nature of learning science has been widely advocated in the literature (Cano, 2005; Thomas and McRobbie, 1999; Brookes, 1998; Masi *et al.*, 1998; Kember and Gow, 1989 and Van Rossum and Schenk, 1984). Dahl, Bals and Turi (2005, p. 271) conclude, in this connection, that students' ideas about knowledge and learning affect not only their achievement but also "decisions made in during the learning process". Thomas and McRobbie (1999, p. 668) argue that "just as teachers conceptions of teaching, learning and their roles as teachers are barriers to teacher change" students' conceptions of learning and their roles as learners can act as barriers to learning and student change. The way we understand learning science, however, depends upon the theoretical position we adopt (Hodkinson, 2005). The theoretical position adopted in this study is constructivism. Constructivism, however, is not a unified theory. There are several varieties of constructivism (Liu and Matthews, 2005; Phillips, 1995; Matthews, 1994; Sutching, 1992). To some authors constructivism is not a theory of learning. It is a description of the manner in which learning takes place. Cobern (1996, p. 301) for instance, takes constructivism to be "a model of how learning takes place". Similarly, Colliver (2002) considers constructivism to be an important insight into the nature of human learning. In the constructivist perspective learning is using previous knowledge to arrive at new insights. Different learning tasks require different learning skills or strategies. The learner does not need only knowledge of the nature of learning but also knowledge and ability to use various learning skills and strategies as situations demand (Murayama, 2005; Harlen, 2002; Fairbrother, 2000; Garner, 1990; Wittrock, 1986; Weinstein and Underwood, 1985). The review of the literature, in this section brings to the fore learning skills or strategies whose efficacy has been demonstrated in the literature. In this section studies about learning skills and strategies, epistemological beliefs about science and science learning, metacognition and self-regulated learning are reviewed.

5.3.1 Learning skills and strategies

Learning strategies are plans that learners follow in order to attain their learning objectives. These strategies can also be taken to be techniques that are used by learners to achieve their objectives. Karakoc and Simsek (2004) state that learning strategies are clustered around such groups of learning techniques as attention, rehearsal, elaboration, metacognition. Similarly, Mayer (2003, p. 362) defines learning strategies as "cognitive processing performed by the learner at the time of learning that are intended to improve the learning". Mayer classifies learning strategies into three categories namely: mnemonic strategies; structure strategies and generative strategies. Mnemonic strategies are techniques used to improve mental retention of facts. Structure strategies are elaborative learning techniques in which the learner creates a mental structure and attaches information presented to the created structure. Sometimes, elaboration involves relating new information to the information that is already in the cognitive structure of the learner. Hartfield and Buxkemper (2000) for instance define elaboration, in this connection, as a learning technique used to connect material presented in a lesson or text to the material already stored in the learner's cognitive structure. Generative strategies involve integrating presented information in the cognitive structure of the learner. In the same vein, Derry and Murphy (1986) define learning skills as mental tactics used by an individual in a learning situation to facilitate acquisition of knowledge or ability. A learning tactic is a more specific skill that one uses "in service of a strategy" (Derry and Murphy, 1986, p. 2). A group of learning tactics or skills used to facilitate acquisition of knowledge or skills forms a learning strategy

To be successful, however, learners do not only have to know appropriate learning strategies, they also have to use the strategies and monitor their effectiveness. Awareness of nature, purpose and progress being made in a learning task is called metacognition. According to Baird (1998) metacognition has three components: metacognitive knowledge; metacognitive awareness and metacognitive control. Meta-cognitive knowledge is knowledge of three aspects of learning namely: nature of learning; effective learning techniques for the particular learning task and knowledge of the extent to which a learner knows what he or she is doing and why they are doing it. Metacognitive control is the learner's ability to make productive decisions about the learning approach being used and the achievements being made in the course of the learning. Learners' use of metacognitive skills is mediated by their epistemological beliefs, self-efficacy beliefs and motivation. Studies pertaining aspects of learning referred to above are reviewed next.

Mnemonic and elaboration skills

The purpose of learning is twofold: to promote retention and transfer of material acquired in learning situations (Mayer, 2002). Retention is the ability to remember material learned some time later. Transfer is the ability to use material learned to solve new problems, to answer questions that have not been encountered before or to learn new subject matter. Norman cited in Mayer (2003) laments that although students in schools have to remember large bodies of material, little effort is made to teach them memory skills. Since the majority of questions on tests in secondary schools required students to recall specific facts (Mastropieri and Scruggs, 1998), memory skills are important to secondary school students. Mayer (2002) asserts that ability to use information presented in a lesson in a new situation presupposes ability to remember that information. Memory skills are hence critical for students' success in learning. Goll (2004) concurs with Mayer when she states that efficient memory strategies facilitate performance in higher order thinking and transfer tasks. In these tasks success depends on remembering the appropriate factual material.

In her book on human learning, Ormrod (1990) identifies four types of mnemonics: verbal mediation, visual imagery, superimposed meaningful structures and external retrieval cues. Mastropieri and Scrugg (1998) provide a list of general techniques for improving memory in addition to specific mnemonic techniques. Among the general techniques for enhancing memory are; increasing attention, promoting meaningfulness, using pictures, promoting active manipulation, promoting reasoning, minimizing interference and increasing the amount of practice. Among the specific mnemonic techniques the authors have the keyword method, the pegword method and letter strategies. The keyword method is essentially a grouping method in which the key element of a group helps one to remember all elements of the group. In the pegword method items learned are mentally attached to items that have already been learned. Letter strategies involve using letter prompts to remember things. Utah State University Academic Program (2006) adds place method in which places are associated with distinct items to be remembered and the link system which is used when items have to be remembered in sequence, as means of enhancing memory. Mastropieri and Scrugg (1998) recommend that to reduce failure in schools, teachers should teach students "how to remember as well as what to remember" (p.11). The memory strategies reviewed so far lead to verbatim recall with minimal processing of information in the learner's mind. These memory strategies deteriorate to rote learning when meaning gets divorced from the content learned. Elaboration is an exceptional memory strategy in so far as it requires integration of the new content in the learner's prior knowledge.

Elaboration is a learning technique that forges a link between what a learner is trying to learn and what he or she already knows, so as to make the new material more personally relevant and meaningful (Weinstein, Ridley, Dahl and Weber, 1989; Pressley, 1982). When learners consciously focus on their prior knowledge, experiences images and beliefs while attempting to learn new knowledge, they build bridges, as it were, between the new information and what they already know. These bridges create personal meaning and make the new information more memorable to the student (Weinstein *et al*. 1989). Pressley *et a*l. cited in Willoughby, Porter, Belsito and Yearsley (1999) suggest that asking and answering questions about new content is a particularly effective elaboration strategy. The question-asking strategy of elaboration is called elaborative interrogation. The questions asked should provide a variety of different elaboration techniques such as analogies, transformations, comparing-contrasting or imagining (Weinstein *et al*. 1988/1989). Students, during elaboration expand what was learned previously to include new material through the use of these techniques. The efficacy of elaboration techniques has been demonstrated empirically. Willoughby *et al*. (1999) worked with 134 students (69 males and 65 females) drawn from grades 2, 4 and 6 in four elementary schools in a midsized Canadian city to compared the performance of students placed in three different memory conditions: elaborative interrogation, imagery and keyword. Imagery and keyword students were encouraged to use pictures and keywords, respectively, while the elaborative interrogation groups were encouraged to ask and answer questions, in their learning of facts about eight animals. The numbers of participating students from grades 2, 4 and 6 were 44, 45 and 45 respectively. The students were in each grade assigned randomly to the three memory strategy conditions. Appropriate training was provided to students of each memory condition separately. A memory test was administered at the end of the study. They found that regardless of grade students performed equally well while using the elaborative interrogation strategy. The authors concluded that elaborative interrogation is a powerful strategy "that should be taught in the elementary school classroom" (Willoughby et al. 1999. p. 228). Similar findings have been reported by Grier and Ratner (1996) in their study on elaboration. In the same vein the New Zealand Ministry of Education (2002) concluded from the performance of students who took part the Programme for International Students Assessment (PISA) that developing appropriate memorisation and elaboration strategies is likely "facilitate learning" (p. 5). The importance of elaboration techniques in school learning is firmly established in the literature. This study sets out to determine whether or not students in Malawi use these strategies in their learning at secondary school level.

Beliefs about science and science learning

The seminal work in the study of the relationships between students' learning practices and their conceptions of the nature of knowledge was spurred by William Perry cited in Finster (1989) and Schommer (1990). Perry suggested that the learning difficulties that students experience spring from their views of knowledge (Perry, 1988). He also felt, as previously stated, that the process of schooling may create in students' minds misconceptions about the nature of learning. Perry's study involved interviewing Harvard male undergraduates over their four years of experience in college to trace the development of their conceptions of knowledge. From his study Perry postulated 9 positions or stages in the development of students' conceptions of knowledge. Finster (1989) condenses Perry's 9 positions into four, namely: Dualism, Multiplicity, Relativism and Commitment in Relativism. Dualism is the position where the students see the world as involving opposites such as right-wrong, good-bad, and we-they (Finster, 1989, p. 659). In the multiplicity position diversity and uncertainty in knowledge are recognised as legitimate features. The relativistic position is such that the students who have attained it realise that knowledge is contextual and relative. The commitment in relativism position involves recognising the implications of accepting a particular position about knowledge and being committed to that position and assuming responsibility for that commitment. Belenky, Clinchy, Goldberger and Tarule (1986) criticised Perry's work because of the small proportion of female students in his sample and replicated the study among women only. They report that some ways of knowing are more common among women than men and vice-versa. The main contribution of these authors has been the identification of two forms of knowing: connected knowing that involves an empathic and caring approach to knowing; and, separate knowing that involves a disinterested and impersonal approach to knowing (Hofer, 2001). These findings prompted Magolda to carry out a longitudinal epistemological study of equal numbers of males and females. From her study Magolda identified four ways of knowing namely: absolute knowing; transitional knowing; independent knowing and contextual knowing (Magolda, 1995). Further development in our understanding of epistemological beliefs has been facilitated by the work of Schommer that is reviewed next.

In 1990 Schommer carried out a re-conceptualisation of personal epistemology as a system of independent beliefs. In her re-conceptualisation (Schommer, 1990;

Schommer-Aikins, 2004) parted company with Perry cited in Finster (1989), Magolda (1995) and King and Kitchener cited in Louca, Elby, Hammer and Kagey (2004) who view epistemological development as progression through Piagetian-like stages. These authors suggest that, students' beliefs about knowledge and learning progress from a dualist or objectivist position to a relativist one (Cano, 2005; Dahl et al. 2005; Louca et al. 2004; Cano and Cardelle-Elawar, 2004; Sandoval, 2004; Hofer and Pintrich, 1997). Schommer (1990), however, challenged the idea that epistemological beliefs exist in one dimension. She felt that beliefs were too complicated to be captured in one dimension. Schommer (1990) followed Ryan (1984) in using quantitative approaches to measure beliefs about knowledge. Schoenfeld's (1983) advice concerning the need to incorporate beliefs about learning when studying epistemological beliefs was accepted and incorporated in Schommer's system. Each dimension of an epistemological belief is hypothesised to form a continuum ranging from unchanging knowledge to tentative knowledge in the case of stability of knowledge, isolated bits and pieces of knowledge to integrated concepts in the case of structure of knowledge. Similarly beliefs in source of knowledge range from authorities to reason and empirical evidence and beliefs in the speed of learning range from quick or not at all to gradual. According to Schommer (2004) beliefs about one's ability to learn range from ability to learn is fixed at birth to ability to learn is improvable.

Schommer used insights from previous authors to develop a paper and pencil instrument that has been widely used in the study of epistemological beliefs (Hofer, 2001). Although, Schommer's beliefs factor structure, has not been replicated in some studies (Louca *et al.*2004; Hofer, 2001; Hofer and Pintrich, 1997), her questionnaire "remains the primary assessment of personal epistemology" (Hofer, 2001, p. 360). This study followed Schommer's method of studying epistemological beliefs for three reasons. First, Schommer's work has been acknowledged as a significant contribution to the study of epistemological beliefs (Cano and Cardelle, 2004; Hofer and Pintrich, 1997). Cano and Cardelle (2004) cite Hofer and Printrich

(1997), in this connection, to the effect that Schommer has developed a research programme that is more "quantitative than that of her predecessors and takes a more analytic view of the components of beliefs" (Cano and Cardelle, 2004, p. 170). Second, Schommer's attempt to quantify study of beliefs points to the possibility of using quantitative methods in areas that are otherwise considered only suitable for qualitative methods. Schommer's predecessors Perry, Baxter Magolda and Belenky *et al*. used qualitative methods in their studies of students' beliefs about knowledge. Schommer's use, of a questionnaire to survey students' beliefs about learning has been emulated in this study. Third, vigorous scholarship has developed from Schommer's works. From her study of effects of epistemological beliefs on comprehension (Schommer, 1990, p.503), she concluded:

(a) Personal epistemology can be characterized as a system of more or less independent beliefs;
(b) Epistemological beliefs have distinct effects on comprehension and learning;
(c) Epistemological beliefs are influenced by home and educational background;
(d) Effects of epistemological beliefs exist beyond the influence of variables found to influence comprehension and learning; and,
(e) Effects of epistemological beliefs on learning and comprehension are generalizable across the contents of physical science and social studies.

In a further study, Schommer, Crouse and Rhodes (1992) it was found that belief in simple knowledge is negatively associated with comprehension. The authors speculated that the influence of simple knowledge on comprehension may be mediated by selection of study strategy. In a series of studies Schommer and Walker (1995), Schommer, Calvert, Gariglietti and Bajaj (1997) and Schommer-Aikins (2002) Schommer and her collaborators provide empirical support to the re-conceptualised system of personal epistemology. In their study on schooling and students' epistemological beliefs about learning Jehng, Johnson and Anderson (1993) also provide empirical evidence in support of Schommer's re-conceptualization of epistemological beliefs when they state that their study "supports previous findings that epistemological beliefs are multidimensional" (p. 32). This study was interested in the use of Schommer's questionnaire as a diagnostic tool of students' beliefs about learning.

Students' learning is not only affected by their beliefs about science but also by their beliefs about the nature of science (Marra and Palmer, 2005; Bartholomew, Osborne and Ratclife, 2004; Carey and Smith, 1999; Driver et al. 1996; Lederman, 1992; Songer and Linn, 1991). A spate of studies has indicated the need for teachers to teach nature of science explicitly to students. Abd-El-Khalick, Bell and Lederman, (1998) state in this connection, that "explicit attention to the NOS is essential". NOS is an abbreviation for nature of science. Studies of students' conceptions of the nature of science that are reviewed below were selected to portray the international nature of the scholarly effort to understand what students think science is.

Kang, Scharmann and Noh (2004) used an empirically derived multi-choice format questionnaire to investigate students' views on the nature of science in Korea. A survey questionnaire was administered to 534 sixth graders, 551 eighth graders and 617 tenth graders. The age ranges of students in the sixth, eighth and tenth grades were 11-12, 13-14, and 15-16 years, respectively. The authors developed the items of their questionnaire through adaptation, modification and pilot testing of items found in the science education literature. Students were asked to explain their choice in the multiple-choice items. One item for instance, begins with the statement that "scientists are those who are working on science". The item goes on to say that "To put scientists work in brief, it is...." then four options follow: (A) making new discoveries and adding them to the knowledge of nature; (B) investigating natural phenomena and explaining the reasons for those phenomena; (C) inventing things to make this world a better place to live in (D) other. Space was provided on the questionnaire for an explanation of the choice made.

The authors found that in all questions only a small number of students in the participating grades were found to have scientifically informed understanding of the nature of science. The authors lament that 10th graders were found with views of science that left much to be desired. Since 10th grade is the final year of formal science learning for half of the students, the implication is that students were moving out of the school system into society with dysfunctional views of science. Similar results are reported in Solomon, Scott and Duveen (1996) who administered a questionnaire to 800 students aged 14-15 years and 120 students aged 12-13 years. These authors were mainly interested in students' understanding of the terms "theory and "experiment". The questions they asked students were like questionnaire items used by Kang *et al*. (2004) discussed previously, with the exception that students were not required to explain their responses. The authors found a relationship between students' views of science the the characteristics of the class in which the students were taught science. Their finding points to the overriding influence of teachers on students' ideas of science reported in Brickhouse (1989). Using a Chinese versions of the NOS they developed, Shiang-Yao and Lederman, (2002) investigated views of science among 29 gifted students (10 female and 19 male) in Taiwan. The authors found that the gifted students had basic understanding of NOS, including tentativeness, subjectivity and empirical basis. Although the Chinese sample seemed to outperform some students in previous studies the authors caution that interpretation of their results should take into account the fact that the students were exceptional and gifted students. Students' views of science are an important aspect of learning science hence their inclusion in this study.

Metacognition

Metacognition has three components: metacognitive knowledge; metacognitive awareness and metacognitive control (Baird, 1990, 1998). Metacognitive knowledge is knowledge of: nature of learning; effective learning techniques and, personal learning characteristics. Metacognitive awareness, on the other hand, refers to one's knowledge of the nature of learning task one is carrying out and the progress being made. Metacognitive control denotes decisions about approaches to learning, progress made and learning outcomes that are geared at maximising achievement. Masi et al. (1998) state, in this connection, that there are three components of metacognition: awareness about one's own mental process and knowledge; capacity to strategically manage one's knowledge and learning skills and ability to control one's mental functioning. Ertmer and Newby (1996) in their article of expert learning suggest that expert learners use their metacognitve knowledge and their ability to regulate their learning. Metacognitive knowledge in Ertmer and Newby's (1996) formulation is knowledge of task requirements and knowledge of personal resources. Knowledge of task requirements includes knowledge of the type of learning one is involved in and knowledge of the learning strategies that are considered to be appropriate to the particular learning task one is grappling with. Knowledge of personal resources is in these authors' opinion knowledge of the learner's own prior knowledge concerning the subject at hand and knowledge of the learning strategies that the learner has acquired and can use in a particular learning situation. In similar vein Gunstone (1994) considers learners to be metacognitive if they "consciously undertake an informed and self-directed approach to recognizing, evaluating and deciding whether to reconstruct their existing ideas and beliefs" (p. 133). Brown (1984) argues that metacognitive-like entities 'lie at the main roots of the learning process" (p. 66). To Brown metacognition is one's knowledge and control of one's cognitive system. The science education literature is replete with studies that attempt to demonstrate the relationship between acquisition of metacognitive skills and performance in science education. A selection of these studies is reviewed below.

In their study of effects of metacognitive instruction embedded within an asynchronous learning network on scientific inquiry, Zion, Michalsky and Mevarech (2005), showed that providing students with metacognitive guidance improves their learning outcomes. These authors used four types of learning groups of 10th graders to examine the effect of metacognitive guidance. Two groups involved asynchronous learning networks (ALN), a virtual classroom involving asynchronous interaction and the exchange of information exclusively online. One ALN group was provided with metacognitive guidance the other group was not. Two other groups involved face to face teaching. One face to face teaching group was provided with metacognitive guidance the other was not. A total of 407 students (198 boys and 209 girls) were randomly selected from five high schools in Israel. Teachers involved in teaching metacognitive groups were introduced to the rationale and techniques of the metacognitive guidance method. Tests designed by the researchers were used to pre-test and post-test the students. The authors found that the metacognitive groups outperformed the non metacognitive groups. It was further found that students who studied in the metacognitive ALN group outperformed all the other groups on general scientific ability and inquiry skills. The authors speculate that metacognitive guidance facilitates creation and clarification of connections between concepts in students' minds. These findings concur with those of Aleven and Koedinger (2002) who found that a computer-implemented form of self-explanation, a metacognitive learning strategy, enhances students' learning.

Further evidence of the facilitative role of metacognitive guidance on students' achievement in learning has been provided by Georghiardes (2004). Georghiades worked with 60, year 5 pupils (11 year olds) in Cyprus and showed that children who engage in metacognitive activities achieve a more permanent restructuring of their understanding of electrical phenomenon. The metacognitive activities that were used in the study are classroom discussions, annotated drawing, keeping diary-like notes and concept mapping. The pupils were divided into two classes of 30 pupils each. In the experimental group the metacognitive instruction was incorporated in the normal teaching without allocation of extra teaching time. The two groups of pupils were matched with respect to average scores on a cognitive development test and a test on Year 4 science. Written tests were used to assess students' performance in the course of the study. The study showed that it is possible to implant metacognitive awareness and practices in primary school students and that the students who engaged in metacognitive activities achieved a more permanent restructuring of their ideas about electricity. Similarly Rozencwajg (2003) used 42 seventh graders (12-13 years) in France, to determine how metacognition might account for academic achievement. Qualitative and quantitative methods were used in Rozencwajg study. Rozencwajg found that metacognitive learning strategies were lacking in poor students. She concludes that teaching metacognitive strategies to poor students could be one way of improving their level of academic achievement. Rozencwajg's conclusions is supported by Garner (1990) who argues that her reading of the research literature in the past decade convinces her that "effective learners are strategic when they need to be" (p. 518). If metacognition is so important for success of learning do the students in Form 3 in Malawi use metacognitive skills in their learning? This is one of the questions that the study sought to answer.

Self-regulation

Self-regulated individuals have been defined by Zimmerman (1989), as "metacognitively, motivationally, and behaviourally active participants in their own learning process" (p. 4). Self-regulation involves systematic efforts to control and direct one's thoughts, feelings towards achievement of one's goals (Zimmerman, 2000). In the school situation, self-regulated learners have been characterized as metacognitively aware, planful and strategic learners (Brown, 1984). Academic self-regulation is the process by which students "activate and sustain cognitions, behaviours, and affects that that are systematically oriented toward the attainment of academic goals" (Ruban, McCoach, McGuire and Reis 2003, p. 3). In similar vein Azevedo, Guthrie and Seibert (2004) define self-regulated learning as an active constructive process in which learners set goals for their learning, do things to facilitate learning, monitor, regulate and control not only their cognition but also their motivation and behaviour in order to achieve their learning goals. In his paper on self-regulation, Schunk (2005) concurs with Azevedo *et al*. when he lists four phases of self-regulation namely: forethought, planning and activation; monitoring; control; and, reaction, reflection. In Schunk's view areas for self regulation include cognition, motivation, behaviour and context. It is important to note that self-regulated learners are not "merely reactive to their learning outcomes; rather, they proactively seek to out opportunities to learn" (Zimmerman, 1990, p. 6). In recent years components of self-regulated learning have been increased to include epistemological beliefs (Schommer, 1990, 1993), self-efficacy beliefs (Schunk, 2005; Paris and Newman, 1990; Zimmerman, 1989), goal setting (Schunk, 2002; Zimmerman and Martinez-Pons, 1986) and reflection and constructive attribution (Masui and De Corte, 2005). A spate of studies in this area has showed that students who have the propensity to control their effort to learn and use self regulatory strategies achieve better academic success (Stoynoff, 1996; Manning and Glasner, 1996; Pintrich and De Groot, 1990; Zimmerman and Martinez-Pons, 1990). Studies of self-regulatory learning done at primary or secondary school level are reviewed next. Four studies that are reviewed below are: Yen, Baker, Roslan, Luan and Rahman (2005), Joyce and Hipkins (2004), Ee, Moore and Atputhasamy (2003), and Miller (2000). These studies were selected for detailed review on account of their relevancy to the research questions of this study.

Yen *et al*. (2005) set out to identify the factors of the both the physical context of the learning situation and the social experiences that students have during the learning processes, in smart schools in Malaysia. Smart schools are schools in which information technology (IT) is utilised in every aspect of education. In such schools IT tools such as personal computers, educational software and the Internet are used to promote self-learning among students. The authors examined the relationship between 6 factors and their relationship to self-regulated learning. Among the factors examined were: students' levels of IT-integration, student-teacher interactions, motivational beliefs, self-regulative knowledge, information literacy, and attitudes towards IT.

A total of 409 students whose average age was 16 years were sampled from a total population of 90, 000 students using cluster sampling methods. Instruments used to collect data included items on self-regulated learning taken from the Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich, Smith, Gracia, and McKeachie, 1991), Student-Teacher Interaction Scale developed by the researchers, Motivation Scale drawn from MSLQ, Self-Regulative Knowledge Scale written in Malay by the authors. Other instruments developed by the authors were used to measure information literacy and students' attitudes to IT. The authors found that motivational beliefs predict self-regulated learning scores. Other predictors of self-regulated learning found were IT-integration, student-teacher interactions, and self-regulative knowledge. The authors advise that explicit teaching of learning strategies may enhance students' self regulated learning. The implication here is that without knowledge of learning strategies students can hardly develop into self-regulated learners. The authors argue that their study demonstrated the importance of motivational beliefs to self-regulated learning. In their view, students need not only to know when, why and how to use learning strategies "but they must also be motivated to use them" (Yen *et al*. 2005, p. 351). Thus it is not sufficient to find out whether students have knowledge of learning strategies without determining the extent to which the students are motivated to use the strategies in their learning.

Joyce and Hipkins (2004) investigated self-regulated learning in a primary school during science lessons. These authors worked with Year 1, 2, and 3 children who were supported to develop emergent self-regulation skills in science investigations. Their study explored ways in which the classroom environment set by the participating teacher empowered the children to develop observable emergent self-regulation skills. In the preliminary phase of the study the authors observed four 6- and 7-year old students (two boys and two girls), working on a science investigation set by the authors. The students were asked to investigate the distance cans containing different substances would roll down a ramp. The authors found no evidence of self-regulated learning when the students worked alone. All the students were provided with extra tuition to improve their writing skills.

In the exploratory phase of the study, the authors worked with the classroom teacher to develop a series of four lessons that were presented to students by the teacher. These lessons provided support to developing both concepts involved and investigatory skills. The class they worked with included the four students who participated in its preliminary phase. The four lessons were taught by the teacher while the researchers observed on four consecutive days. The first lesson was a free exploration one. Students were given marbles and balls and were asked to investigate the rolling of these items on different surfaces that were also provided. The second lesson used the Predict, Observe, Explain (POE) strategy (Palmer, 1995), to elicit predictions about the objects that would roll faster on the various surfaces and to test the prediction through measurement. During this lesson the teacher modelled principles of fair testing and thought aloud about these principles to communicate them to the students. The students carried out a structured investigation during the third lesson. They investigated whether a jar of cotton wool would roll further compared to a jar of water. The fourth lesson involved an independent lesson of the extent to which a can of cat food would roll compared with a can of soup.

Among the emergent self-regulatory skills that the authors observed were: motivation and self-efficacy; awareness of learning strategies; managing both conceptual and physical distractions; self-monitoring; drawing on previous experience and sustaining learning. The authors draw on findings of Zimmerman and Kitsantas (1997) to suggest that self-regulatory learning skills do not develop in a quantum manner from zero to maximum value but develop in stages. Zimmerman and Kitsantas identify four states to acquiring self-regulated learning skills. The stages are observation, imitation, self-control and self-regulation. In their paper on social origins of self-regulated competence Schunk and Zimmerman (1997) argue that self-regulation is a domain specific level of acquired skill that depends on such task-dependent processes as "planning, strategizing, developing motoric proficiency, and self monitoring" (p. 199). In the view of Schunk and Zimmerman (1997) self-regulatory skills develop initially from social sources of academic skill and subsequently shift to self sources following the stages outlined in Zimmerman and Kitsantas (1997) as previously presented. The implication of these arguments is that students should be guided in developing emergent self-regulatory skills in the primary schools if they are to use self-regulatory skills in secondary schools. This study set out to determine the self-regulatory skills, if any that secondary class 3 students in Malawi use in its efforts to explore the problem of poor performance in science subjects in national examinations.

Ee *et al.* (2003) investigated the relationship among students' motivational goals, self-regulation, achievement, teachers' goals and instruction among high-achieving primary school students in Singapore. Their sample consisted of 566 high-achieving Primary 6 students and 32 teachers who were teaching in the high-achieving classes in 34 schools in Singapore. The high-achieving students constituted the top 10% of the total Primary 6 population. The majority of the teachers were non degree teachers who had undergone three years of pre-service primary teacher training. Data on academic achievement of the students was obtained from the Primary Six Leaving Examination results. The other instruments used in the study were adaptations from published instruments. Goal orientations were measured by a Personal Goal Scale adapted from Nicholls, Patashnick and Nolen cited in Ee *et al*. (2003) and knowledge and usage of self-regulation were measured by a scale adapted from the Self-Regulated Learning Strategy Scale of Youlden and Chan cited in Ee *et al*. (2003). Teacher level factors were measured by the Teacher Survey Questionnaire developed by Ee cited in Ee *et al*. (2003). The authors used SPSS, Release, 7.5 to determine descriptive statistics of their data. The results indicate that all high-achieving students scored higher on task and ego orientations than on work avoidance orientation. The authors further report a greater tendency towards task orientation than ego orientation among the high-achieving students. Although the high-achieving students indicated that they frequently had knowledge of their self-regulated learning strategies, they also reported that they used these strategies only occasionally. The findings of these authors make sense when one assumes that use of self-regulatory strategies develops in stages. The high-achieving Primary six students that Ee *et al* (2003) investigated were in the process of developing self-regulatory skills and were not yet self-regulated learners.

Miller (2000) provides more insights in support of the findings of the previously reviewed studies. Miller explored the source of self-regulated learning through comparisons of internal and external influences on the development of these skills. Miller followed VanderStoep, Pintrich and Fagerlin (1996) in assuming that self-regulated learning capability beliefs are domain specific. Her study sought to determine the ways in which students cultivated self-regulated learning skills in two content areas, (English and mathematics). Her sample consisted of 297 (170 female and 122 female) Junior and Senior high school students attending mid-Western schools in urban, suburban or rural areas. The participants were predominantly Euro-American middle-class adolescents attending a workshop in preparation for college entrance examinations. Bandura's (1989) self-regulated learning subscale drawn from his Multidimensional Scales of Perceived Self-Efficacy was used to measure students' perceived capability to use various self-regulated learning strategies. General strategies such as concentrating on schoolwork, organising schoolwork and taking part in class discussions were measured. The subscale was adapted by the researcher to allow for assessment in both English and mathematics content areas. Students' achievement was measured with retired items of ACT Assessment sample tests. The predicted pattern of relationship was tested with conventional path analysis as presented in Pedhazur (1997). The authors found overall that the use of external or referential comparisons appeared to be stronger than use of internal comparisons among the students. The authors suggest that acquiring self-regulated learning beliefs strictly from peer contact 'may result in inaccurate perceptions' (Miller, 2000, p. 51). These findings agree with Schunk and Zimmerman's (1997) thesis that states that self-regulatory competences originate in social actions. In the Malawi situation these studies suggest that one is unlikely to finding full-fledged self-regulating students in learning environments that have no aims for developing such skills. Knowledge elements of self-regulated learning can, however, be found among the Malawian students since they are likely to be in one of Zimmerman and Kitsantas's (1997) three stages of development of self-regulatory competences that preceed the self-regulatory stage.

5.4 General summary of the literature review

The purpose of this study was to explore the problem of poor performance in science subjects in national examination in Malawi. This chapter has teased out clues about the nature of the problem and its possible solutions. The summary of the reviewed literature is presented from the perspectives studies done in Malawi, Africa and other parts of the world.

Studies conducted in Malawi have taken the problem of poor performance in the country as similar to problems of poor performance in other countries. There is, however, reason to believe that more has yet to be done to identify the nature of the problem and to propose sustainable solutions to it. The latest study of the problem of poor performance in science in Malawi Mbano (2003), for instance, points to students' approaches to learning as a possible clue to the problem. In 1962 Phillips Commission suggested that the poor quality of primary school graduates was a factor in the performance of students at secondary level. Chipembere (2000) indicates how traditions established in the colonial period remain unchanged in the post-colonial era. Sternberg (2003, p. 8) concurs with Chipembere when he writes "entrenched educational structures whatever they may be are difficult to change". It seems that there are traditions among students in Malawi that affect students' approaches to learning and may partly account for their poor performance in science. This study set out to identify the factors through investigation of students' learning.

Studies done in Africa have helped to widen my understanding of the problem of poor performance in science. The discovery of differences in the performance of ethnic groups at secondary level (Adigwe, 1997; Mordi, 1993) support my suspicion that things that happen before secondary education may account for the poor performance of students in developing countries. Studies done in African countries have also highlighted the dissonance between children conception of learning as derived from their societies and the concepts of learning that are embedded in science learning materials (Peacock, 1995). Ogunniyi (1996) refers to students' preference to memorising content rather than to solving problems as a way of learning. When students use inappropriate learning styles, it is reasonable to assume that their performance will be poor. The question that begs for an answer, after reviewing the science education literature pertaining to African students, is "what do the students do to learn the scientific knowledge and skills that are presented to them in science lessons? This is one of the questions that this study set out to find answers for.

The literature portrays an inconsistent picture of performance of girls, vis-à-vis boys in science. Some scholars such as Benbow (1993) and Benbow and Stanley (1983) have reported gender differences in favour of boys especially in the top 1% of the ability band. Other studies such Francis (1998) and Demie (2001) have reported that girls were now out-performing boys in traditionally masculine subjects such as mathematics and science. The thrust of the evidence presented in the studies is that gender differences can be minimized through purposeful action to that effect.

Ogbu's (1992) work on cultural diversity and learning provided another dimension to this study. Ogbu argues that one reason that leads to failure of educational efforts aimed at improving the performance of minority groups is that minority students generally ignore own responsibility for their academic performance. Furthermore Ogbu claims the relationship between the predominant culture and the minority culture is critical in determining performance of students of the minority groups. In Africa where the predominant cultures changed at independence, there is a possibility students may continue to behave as if their relationship with the predominant culture has not changed. In this connection the study focused on the relationship between teachers and students and on the extent to which the students take responsibility for their learning.

The literature on science and science learning provided me with tools as it were for diagnosing learning endeavours among the students and determining the extent to which the students in Malawi have attained the self-regulated status in their learning of physical science. Throughout the study I have searched for students' beliefs about the nature of science (Lederman, 2003; Musante, 2005) and the nature of science learning (Schommer-Aikins, 2004; Somuncuglu and Yildirim, 1999) among the students. The literature reviewed provided me with beacons that directed my search for factors that bring about underachievement in science among pupils in Malawi. The next chapter discusses the methods used in collecting and the methodology of the study

Chapter 6

Research Design, Methodology, Methods and Procedures

6. Introduction

This study explored the problem of poor performance in physical science in secondary schools in Malawi from the perspectives of students' conceptions of science and science learning. The first five chapters of this thesis have: presented the research questions and the concepts that under gild the study; related the story of science education in Malawi; described the context of the study and teased out relevant ideas and insights from extant literature. This chapter explains the research design, presents the research strategy chosen for the study and discusses the methods used in collecting and analysing data. The chapter opens with a brief recapitulation of the theoretical framework and research questions of the study. Then follow rationale for converging qualitative and quantitative methods in the study and for choosing case study as the most appropriate research strategy for answering the research questions. The research design, methods and procedures used in collecting and analysing data, criteria for assessing adequacy of data collection and analysis, and ethical issues are also discussed in the chapter. The chapter ends with a section on the demarcation of the thesis.

6.1 Recapitulation of theoretical framework and research questions of study

The theoretical framework of this study has been presented and discussed in section 1.6 and in chapter 4 of this thesis. What follows is a recaptulation the theoretical frame work and research questions to set the scene for the presentation of the procedures, methods and methodology of the study.

Since World War II (1939-1945), the importance of students' beliefs and ideas in science learning has been frequently alluded to in articles published in research journals in science education (Shapiro, 2004; Keeves, 1998; Driver and Easley, 1978; Doran, 1972). Shapiro (2004), for instance, states that in the aftermath of the Second World War, there has been a dramatic rise in the acknowledgement of students' beliefs and ideas "as key in understanding students' learning" (p. 2), among researchers in science education. The conceptual change approach to science education is based on the understanding of importance of prior conceptions in students' learning as indicated in section 5.2.2 of this thesis. Similarly the worldview approach to science learning recognises the importance of worldviews that students adopt before learning science. Shumba (1999), for example, takes a worldview to be an overall perspective from which an individual views and interprets events and phenomena. These cognitive approaches to science learning developed into the constructivist view of learning. Terhart (2003, p. 34), states that one of the highest-level characteristics of constructivist learning is the development of individual "thinking tools, as well as generally becoming aware of one's own thinking and learning as well as its processes". Development of individual learning skills or tools for learning and becoming aware of ones' learning processes are central issues in the constructivist perspective on learning. The data collected in this study were interpreted from this perspective. The purpose of a study and the nature of its research questions should determine, to a large extent, the paradigm or paradigms adopted in a study. In the following paragraphs, I discuss the nature of the study to show how the contructivist paradigm was selected as an appropriate paradigm for the study.

6.1.1 Purpose of the study

The purpose of this study was to explore the problem of poor performance in science among students in Malawi from the perspective of the students' ideas of science and science learning. It has been demonstrated in the science education literature that, students' concepts of learning determine their approaches to learning any content (Dahl, Bals and Turi, 2005; Dart, Burnett, Purdie, Bolton-Lewis, Campbell and Smith, 2000; Marton and Booth, 1996; Schommer, 1990; van Rossum and Schenk, 1984). Similarly, it has been shown that students' conceptions of science determine their approaches to science learning (Marra and Palmer, 2005; Bartholomew *et al.* 2004; Lederman, 1992; Songer and Linn, 1991). The study sought to diagnose, as it were, the learning of science through students' constructions of science, science learning and of themselves as learners of science. In diagnosing students' learning the study focused on both cognitive and affective factors. Affective factors tended to be ignored compared to cognitive factors in studies in science education in the 1980s (Laukenmann, Bleicher, Fub, Glaser-Zikuda, Mayring, von Rhoneck, 2003; Pintrich, Marx and Boyle, 1993). This study adopted social cognitive approach to learning in which affective factors, like cognitive factors, play critical roles in students' achievements (Kang, Scharmann, Noh and Koh, 2005; Martin, 2004; Cheung, 2004; Zimmerman, 1990; Hidi, 1990; Dweck and Leggett, 1988). Both the skill and will to learn were the foci of this study.

6.1.2 Nature of the research problem

The research problem being investigated in this study has international national, national and individual characteristics. The problem of poor performance of students in science is an international problem in so far as it is experienced in many nations (Ogunkula, 2000; Hungwe, 1994; Lewin, 1993; Mordi, 1993). Naidoo (2003) for instance, reports that in 1993 only 16% of African students in South Africa passed their matriculation examination in physical science. The severity of the problem in Malawi, however, suggests existence of factors that are peculiar to Malawi that have aggravated it in the past. The problem is an individual, national and international one. Given the extensive dimensions of the research problem, a mixed method approach was considered necessary. Knowledge of individual understanding of learning of learning tasks and group trends concerning learning among students in the country was sought in order to understand the problem. The study thus combines features of qualitative and quantitative research paradigms. In combining in depth probes of the way students think about science and science learning and widely administered surveys that provide data on prevalence, the study was following a well bitten trail in physics education (McDermott, 2001). Additional reasons for combining qualitative and quantitative research methods are presented later

As indicated in chapter 2, the problem under investigation has had a long history. Layder (1993, p. 173) maintains that "tracing historical antecedents of the social phenomenon that is being investigated is an absolute necessity". In similar vein

Schwadt (1994, p. 120) asserts that as human beings we do not simply live "out our lives in time through language; rather we are our history". This implies that one's history sets the limit for one's abilities and achievements. It is argued in this study that the experiences that children have had in primary school set the limit to what they are able to do in secondary school when appropriate interventions are not implemented at the secondary level. In addition Sternberg, (2003, p. 8) states that "entrenched education structures, whatever they may be, are difficult to change". The historical dimension of the study aims at identifying any long established traditions or structures in the education system in Malawi that may facilitate understanding of the peculiar performance of the students in science subjects.

The national nature of the study dictated cross country collection of data. This led to the use of survey methods. Interviews were also conducted in various schools scattered across the country. The study was conducted in stages beginning with examination of documents followed by a survey of students' views about science and science learning that was further followed by individual and group interviews on the same subject. The interviews constituted the main thrust of the study and were based on the constructivist paradigm. The constructivist paradigm has been discussed in chapters one and four, only special features of the the paradigm that are directly relevant to the methodology of the study are discussed next.

6.1.3. Constructivist paradigm

The point of departure of this study is the assumption that the ideas and beliefs about science and science learning that students have determine their approaches to science learning and, subsequently their success or failure in science learning tasks, when other factors are controlled. The constructivist view of learning holds that knowledge is not acquired mechanically it is actively constructed by the learner (Liu and Matthews, 2005; Ishii, 2003; Naylor and Keogh, 1999). Lauzon (1999) defines constructivism as a philosophical position that maintains that although learners may experience reality directly, "meaning is constructed" (p. 262). Similarly, Sewell

(2002) states that in the constructivist theory, learning is "not the result of teaching: rather it is the result of what students do with the new information they are presented with" (p. 24). The implication here is that learning takes place when learners use information they are presented with to build an internal representation of the knowledge or devise individual interpretations of their experiences. In constructing knowledge students are constrained by their prior conceptions and by the offerings of their learning environments. Students' prior conceptions act as goggles through which they see new information. To facilitate learning it is sometimes necessary for learners to 'change the goggles they wear'. This study set to determine the goggles about science and science learning that secondary class students in Malawi wear.

In terms of nature of reality, constructivism assumes a world in which universal and absolute realities are unknowable (Hatch, 2002; Glasserfeld, 1991). Objects of research are not measurable phenomena but individual perspectives or constructions of reality. While acknowledging the possibility of commonality of constructs across social groups, constructivists maintain existence of multiple realities that originate in the uniqueness of individual experiences and perspectives. Individual constructions of reality, hence, constitute elements of knowledge that researchers look for. These elements of knowledge are, however, co-constructed by the researchers and their respondents. Knowledge produced in research based on the constructivist perspective takes the form of either case studies or in-depth descriptions or interpretations that are co-constructed in course of interacting with respondents. In the next section I present rationale for combining qualitative and quantitative methods.

6.2 Rationale for merging qualitative and quantitative methods

The difference between qualitative and quantitative research methods has been widely acknowledged in the literature (Smeyers, 2001; Sogunro, 2001; Bryman, 1988; Halfpenny, 1979). The 'paradigm wars' that were waged in the pages of the *Educational Researcher* (Salomon, 1991; Gage, 1989; Howe, 1988) have since subsided and sporadic calls for mixing quantitative and qualitative methods are made by some researchers from time to time (Gorard, 2005; Onwuegbuzie, 2004; Sogunro, 2001; Jick,1983). Rizo (1991), however, cautions that these 'wars' are likely to survive beyond 2009, the reference year set by Gage (1989).

In this study I take no side in the paradigm wars. Silverman cited in Denzin (1994) considers all social action to be situated and unique so that the same unit of behaviour or experience can never be observed more than once. If all social behaviour and experiences are as unique as Silverman suggests, there is no basis for commonality of behaviours and experiences, and insights gained from one study would make no contribution to another study. In this same vein, Bryman cited in Gorard (2005), and Guba and Lincoln (1994) argue that qualitative and quantitative methods carry different ontological and epistemological commitments so that insights gained in a quantitative study cannot inform findings in a qualitative study and vice-versa. As Gorard (2005, p.2) points out, however, "it is important to realise that 'qualitative' and 'quantitative' are not different research paradigms" in the sense in which Kuhn uses the term (Kuhn, 1970). Henwood and Pidgeon (1992) concur with Gorard (2005) when they refer to a "concern to avoid viewing qualitative and quantitative methods as deriving from incommensurable paradigms" (p. 100). The Copernican paradigm for instance, can be considered to have been incommensurable with ideas of Ptolemy about the nature of the Universe. The Copernican ideas superseded Ptolemy's ideas on the nature of the Universe. In the limit, as time tends to infinity, it is not envisaged that qualitative methods will replace quantitative methods nor will quantitative methods replace qualitative ones. This implies that the two paradigms will exist side by side for a long time to come. Guba and Lincoln (1994) admit that both kinds of studies; quantitative and qualitative "have utility" (p. 89). Guba and Lincoln (1994, p. 90) further assert that only "assessment of fitness to the area under study" should determine whether a researcher is to use qualitative or quantitative methods. These authors, nevertheless, consider the schism between qualitative and quantitative to be such that insights gained in one kind of study cannot inform a study of another kind.

Garrick (1999), however, observes that there is no knowable social reality beyond "the signs of language, image and discourse" (p. 152). In his view, knowledge of an individual is not unique to the individual because it is derived from the society in which the individual lives. Similarly, Bencze (2005, p. 1) argues:

> While many theorists emphasize each person's right and tendency to construct unique meanings, many people also believe that these are not completely unique. Simply put, because we share common languages and conduct much of our thought through language and other communal symbols, many agreed that knowledge is socially constructed, even while an individual is thinking. In a sense an individual's thought is never his or her own.

According to the excerpt above, both uniqueness and commonality of individual constructs are to be expected. The uniqueness springs from the unique experiences of individuals while the commonality originates in the culture and language of the society in which the individual lives. Quantitative methods can hence be used to assess the commonality of individual constructs in a population while qualitative methods can be used to probe for in depth understanding of individual constructs. The use of both qualitative and quantitative paradigms is clearly manifested in resolution of conflicts. In resolving a conflict between two nations, for instance, it is necessary to understand the nature of the conflict in words and to know what the majority of the citizens in both nations consider to be an acceptable settlement of the conflict. Understanding the nature of a conflict calls for qualitative methods while determining views of the majority calls for quantitative methods. One kind of information in the conflict situation is no substitute for the other. Similarly in exploring the research problem of this study, qualitative data is no substitute for quantitative data and vice versa.

Increasingly in recent years, the two research paradigms are being accepted not as incommensurable ways of doing research but as complimentary ways of "seeing and understanding the world" Hughes (1997, p. 413). Similarly, Husen (1997), and Hartley and Chesworth (2000) consider the two research paradigms to be complimentary rather than exclusive to each other. Hartley and Chesworth write about the need to follow up issues arising from a qualitative study with a quantitative study and *vice-versa*. In the same vein Eisner cited in Segunro (2001, p. 8) refers to the need to avoid "methodological monism" in the field of education. Miles and Huberman (1994) argue that linking qualitative and quantitative data enables researchers to confirm findings through triangulation, to provide richer detail and to initiate new lines of thinking through paying attention to "surprises and paradoxes" (p. 41). These authors follow Firestone (1987) in arguing that quantitative studies convince readers through "de-emphasizing individual judgement and stressing the use of established procedures" while qualitative studies convince readers through "rich depiction and strategic comparison of cases" (Miles and Huberman, 1994, p. 41). There is hence ample support in the education literature for using quantitative and qualitative research methods in one study.

In this study qualitative and quantitative methods were combined because of two reasons. First, the problem being investigated is a national problem. To achieve better understanding of its dimensions and severity among the highly selected secondary school students, it was felt necessary to converge, both broad numeric descriptions of quantitative research and in-depth naturalistic inquiries of qualitative research. The use of two research paradigms enabled me to triangulate results found in the study. In the anonymous part of the questionnaire used in this study, for instance, students were asked to name what they consider to be the greatest obstacle to their success in learning physical science. In the interviews a similar question was asked. Comparison of students' responses provided a means of confirming the accuracy of the data collected in two modes of data collection.

Triangulation of qualitative and quantitative data was also meant to facilitate completeness of the data collected. Different kinds of knowledge are gained through use of different methods (Foss and Ellefsen, 2002). Historical knowledge of the problem under investigation is arguably necessary for fuller understanding the problem. Such historical knowledge could not be gained through in-depth interviews of students but through examination of documents. Similarly, knowledge of the spread and severity of the problem in various schools in Malawi was gained by carrying out a survey. Various dimensions of the problem called for use of various methods. As Warwick (1993) maintains, the reason for using data collecting instruments based on different paradigms was to obtain important information that could not be obtained using methods drawn from one paradigm. In summary the study sought to use the strengths of each method of doing research to achieve a fuller understanding of various aspects of the problem under investigation. Rationale for adopting the research methodology used in the study is presented next. The research methodology used in the study was case study.

6.3 Reasons for adopting a case study approach to the problem

According to Hatch (2003) case studies are investigations of contextualised contemporary bounded phenomena. Stake (1994) also refers to case studies as bounded systems and so does Merriam (1998). In Stake's view choosing to do a case study, is not synonymous with choosing a methodology but with choosing the "object to be studied" (Stake, 1994, p. 236). A case study is defined by both, its boundaries and the object being studied. The object being studied is called the unit of analysis (Hatch, 2003). The unit of analysis of this study are the conceptions about science and science learning and of themselves as learners of science that secondary class 3 students in Malawi hold. These conceptions were co-constructed by the students and the researcher in interviews that were conducted in the course of the study. The object of study hence exists in a specific, unique and bounded system. My aim in the study was to understand the object so as to be able to say something about it at the end of the study. An intrinsic case study with instrumentalist aims seemed to be the most appropriate study strategy to use in the study. Stake maintains that an intrinsic case study is undertaken when one wants better understanding of a particular case (Stake, 1994). My aim, however, was not merely to understand poor peformance in Malawi but also to understand issues affecting science education in developing countries. The case study strategy provided the best plan for understanding the problem and answering the research questions of the study.

One of the main criteria used in choosing a research strategy for a study is the fit between the nature of the research problem, the research questions and the research strategy being considered. The case study research strategy provided the best fit between the problem under investigation, the research questions and the research strategy. Merriam (1998, p.28), states that "case study does not claim any particular methods for data collection or analysis". According to the author any and all methods of gathering data can be used in a case study. This feature of case studies suited the purposes of this study of merging quantitative and qualitative methods and of including a historical dimension of the problem in the study. The various methods provided for triangulation of the data and method as previously stated. For instance, students' attributions of success or failure in their studies were assessed through their responses to a free-response item in the questionnaire and to some items in the interview protocol. Similarly, students' academic self-efficacy was assessed through items on the questionnaire and relevant items in the interview protocol. In this manner data gathered through one mode was compared with data on the same topic but collected through a different mode to check it's trustworthy.

Besides providing good fit between the aims of the study and its research strategy, the nature of the problem itself pointed to case study as the most appropriate research methodology for the study. Yin (1994, p. xii) states that a case study approach is useful when "phenomena and context are not really separable as conditions that occur in real life but cannot be easily duplicated in the laboratory". The problem under investigation occurs in real life and cannot be separated from the students in secondary schools in Malawi. It is hence a suitable problem for exploration with case study research strategy.

Furthermore, Yin (2003) suggests that one of the criteria to be used in choosing research strategies is the form of the research questions asked. According to Yin the "how "and "why" questions are relevant for case study strategy. Yin (2003) explains that when research questions are mainly "what" questions as is the case in this study two possibilities arise. The "what" questions can either be exploratory questions or can be a different form of "how many" or "how much" questions. The "what" questions of this study, are all exploratory questions. According to Yin (2003) all research strategies can be used in an exploratory study. This study is an exploratory study and has chosen to use the case study strategy.

6.4 Research design

This study is a mixed- or multiple-methods study design (Johnson and Onwuegbuzie, 2004; Creswell, 2003; Onwuegbuzie, 2002; Polit, Beck and Hungler, 2001; Mullen, 1995; Reinharz, 1992; Jick, 1983). The study falls into three parts:

1. Analysis of documents and archives pertaining to the problem of poor performance in science.
2. Questionnaire survey of science learning.
3. In-depth interviews of selected students about science and learning physical science after classes.

These parts of the study were done in the numeric order shown above. As stated previously the first part of the study fed into the second part and the second part fed into the third part. The historical dimension of the study provided the necessary knowledge of the nature of the problem and scholars' perceptions of it in the past. The problem of poor performance of students in science, for instance has in the historical documents consulted, been variously attributed to poorly run primary schools (Rep. Dep. Ed, 1942), unwillingness of Malawi students to work hard in the year following the one in which they passed a national examination (Rep. Dep. Ed, 1953), poor teaching of science and mathematics of the missionaries (Chipembere,

2002) or long established tradition of poor performance in science and mathematics (Chipembere, 2002). These insights from the history of the problem provided avenues for its exploration. Knowledge culled from the history of the problem constituted an invaluable back ground to understanding of the problem. The study overall plan for answering the research questions is shown in Table 6.1 below

Table 6.1 Data collection planning matrix for the study

Aspect of research & reason for inclusion	Kind of data required and source	Location of data and contact person	Time frame
1.History of problem Provides background	Records and Arhives- National Archives	National Archives Director of Archives	June to Dec. 2003.
2. Self-efficacy An aspect of learning	Interview & questionnaire Students	Schools Heads of schools	Jan. to Dec. 2004
3. Learning skills used An aspect of learning	Interviews & questionnaires Students and teachers	Schools Heads of schools	Jan. to Dec. 2004
4. Metacognitive skills used An aspect of learning	Interviews Students and teachers	Schools Heads of schools	Jan. to Dec. 2004
5.Epistemological beliefs An aspect of learning	Interviews and questionnaire Students and teachers	Schools Heads of schools	Jan. to Dec. 2004
6. Students' ideas of science An aspect of learning	Interviews and questionnaire Students and teachers	Schools Heads of schools	Jan. to Dec. 2004
7.Attribution of success or failure An aspect of learning	Interviews and questionnaire Students and teachers	Schools Heads of schools	Jan. to Dec. 2004

Data on performance of students in national examinations from 1984 to 1993 and from 1999 to 2003 was collected from the National Examinations Board in Malawi.

6.5 Procedures used in collecting and analysing data

Many research methods were used to increase the possibility of obtaining trustworthy data and drawing useful conclusions about the problem. The methods used were:

- Analysis of historical documents, records and achives
- Administration of a Likert-type questionnaire
- Administration of free response anonymous questionnaire
- Conducting individual and group interviews

The procedures used in selecting documents for study, developing questionnaires and conducting interviews are presented below.

6.5.1 Selection of documents and records for study

The documents used in the study were drawn from the Malawi National Archives and from the Special Collection section of the library at Chancellor College a constituent college of the University of Malawi. To select documents for this study, I viewed the titles of all education documents in the Malawi National Archives in Zomba, the Special Collection section at Chancellor and Nyasaland papers in the Public Record Office in London available on microfilm in the library at Chancellor College. Documents that appeared to be relevant to the study were jotted down in a notebook. I then perused through the selected documents to determine whether they were worthy a detailed study. In this manner the documents that are listed in table 6.2 were selected for in depth study.

Table 6.2 Documents and records selected for in depth study

No.	Title of document	Brief summary of contents
	Biology and its place in native education by Prof. J. Huxley, 1931.	Report commissioned by the Advisory Council of Education in London aimed at determining whether it was opportune time to start teaching biology in East African Territories.
1	Correspondence on Prof. Huxley's report.	Reactions of missionaries and government officers to Prof. Huxley's report, 1932.
3	Christian education in Africa, Report of Conference held at High Leigh Hodderstone, 1924	Recommended preparing Africans for hospital work and for other "callings for which Africans are eligible" (p. 9).
4	Technical conferences of the East African Dependencies, Report of educationists, 1929	Rejected Prof. Huxley's proposal to start teaching biology on grounds of conflict between biology and religion.
5	Higher College of East Africa Inter-Territorial conference, Makerere, 1938.	Shows British Government's commitment to establish science bases training institution in spite of opposition to science teaching in some colonies like Nyasaland.
6	Minutes of the 12th Session of the Advisory Committee on Education, Zomba 28-29 July 1943.	Cox conveyed the concern of British Government that Nyasaland was in serious danger of being left behind in spite of its past achievements in the field of primary education.
7	Minutes of the Advisory Committee in Education in Nyasaland 7-8 June 1932.	Acting Governor expressed his ideas on education and asked the Committee to be grateful because of late government assistance to education in Nyasaland.
8	CO/525/125, 1928, Vol. 4	Contains a memorandum by the first Director of

Bowring to Colonial Office.	education "education is dangerous unless…"

Documents 1-7 are located in the National Archives in Zomba. Document 8 is available on microfilm in the Library at Chancellor College in Zomba. In addition to the documents in the table above there were also other documents that were consulted such as the Annual Education Reports of the Department of Education and numerous articles, dissertations and books on education in Malawi and Africa.

6.5.2 Likert-type questionnaire

The main strength of survey research is its ability to collect information about students' thoughts or beliefs from a large number of students in a short time with less cost. In this study I wanted to describe the beliefs about science and science learning of about 1, 300 students drawn from a population of about 14,000 students. My interest was merely to describe the beliefs I had no intentions to investigate causal relationships. The questionnaires were administered by the researcher to avoid the low return rates that characterise self administered questionnaires (Michell and Jolly, 1996). The second advantage of the researcher-administered questionnaire was that it provided the researcher opportunity to be available in the classrooms and laboratories where the questionnaires were completed. The researcher was thus able to explain to the students the purpose of the study and aspects of the questionnaire that some students found difficult to understand. This interaction with the students in the course of administration of the questionnaires was good for the study. It helped me to clarify some of the items of the questionnaires to the students to and it enabled me to understand students' responses better. In all schools for instance, students were surprised with the item that asked them to indicate what grade they think they would achieve in the national examinations in the following year, suggesting that they had no plans for their performance in the coming national examinations. In debriefing sessions I pointed out the students the necessity of planning and working for specified grades in various subjects in national examinations.

6.5.3 Free response questions

The free response questions were not originally envisaged in the initial planning of the study. It was the reviewers of the first questionnaire who argued that since the aim of the study is to see the problem of poor performance of students from the perspectives of students themselves, it was important to listen directly to what the students had to say about the problem. I accepted the recommendation of the reviewers and added free response items to the questionnaire. In the free response items, I asked students to indicate what grades they hope to achieve on their School Certificate Examinations and to state what they consider to be the main obstacle to their doing very well in the Malawi School Certificate Examinations. The problem with free response questions is that coding of responses is difficult and time consuming. The design of the questionnaire, however, was such that only two of the free response items had to be coded. In this manner the demands for coding of free response items were kept to a minimum.

6.5.4 Individual interviews

Individual interviews are necessary when a researcher wants to find out what is in the mind of a student. An interview is essentially a conversation initiated "by the interviewer for the specific purpose of obtaining relevant information and focused by him or her on content specified by research objectives of systematic descriptions, predictions or explanations" (Powney and Watts, 1987, p. 6). The interview method of data collection was used because in addition to providing students' responses to the items on the interview protocol, it offered the researcher opportunities to check the correctness of students' responses by asking follow up or probing questions or by asking for physical evidence that would support their assertions. On one occasion during the interviews, for instance, I asked respondents to show me what they claimed to have done in their exercise books. As presented later in this chapter, the questionnaire and interview protocol were changed after the pilot study because it was found that the students were not telling the researcher the truth but what they felt were desirable responses to the researcher's questions. There can be no validity without truthfulness. The students for example, claimed to have made their own notes after lessons. They were, however, not able to show me the notes they had made in their exercise books when I asked for physical evidence that would support their claims. The individual interviews acted as a check on the accuracy of the data culled from the questionnaires and from the interviews themselves.

6.5.5 Group interviews

Group interviews were initially conducted in those schools where the time allocated to the researcher was inadequate for carrying out individual interviews. The questionnaire and interview protocol were such that neither the administration of the questionnaire nor the interviews could be carried over to the next day without lowering the validity of the data collected. Group interviews were at the planning level supposed to enable the researcher to collect a lot data from about 6 students in a short time. During the group interviews, however, it was found that discussions among the students were very lively and provided more information about their thinking than in the one to one interviews where some students hardly spoke a word. The group interviews tended to be used even in the schools that allocated ample time for administering the questionnaires and carrying out the individual interviews. Students were more lively and responsive in group interviews than in individual interviews.

Throughout the study I aimed at cross checking data that students presented to me. The head teachers and science teachers were also asked for their opinion concerning poor performance of students in science. The views of the teachers, however, were not systematically studied since they were not the focus of this study. Teachers' views on the problem served to enrich my background knowledge of the problem. The instruments used in collecting data were developed from standard instruments through a series of pilot studies. The development of the instrument is presented in the next section.

6.6 Development of instruments

Two research instruments: the questionnaire and the interview protocol were developed for use in the study. The development of these instruments is discussed one after another in this section.

6.6.1 The questionnaires

Initially, I planned to use items drawn from questionnaires about students' learning of scholars such as Schommer (1990), Pintrich and De Groot (1990) and Zimmerman and Pons (1986). A questionnaire with most items drawn from the works of these authors was compiled and piloted in two schools. A copy of the piloted questionnaire is available in Appendix A. Analysis of students' responses and subsequent follow up of the responses during interviews revealed a strong desirability bias in the responses of the students, as previously stated. Item 33, for instance, asked students to indicate whether or not they draw relevant diagrams when studying physical science. Although the majority of them strongly agreed with the item, a physical examination of their notebooks in the two schools in which the questionnaire was piloted yielded no student initiated diagrams. Similarly in item 36 no fresh notes were available in students note books although the majority indicated that they made these in their responses to the questionnaire. It seemed that the students aimed at giving the researcher socially acceptable responses rather what they personally felt about the problem. Similar evidence of strong social desirability bias among secondary school students in Malawi was found in students' responses to the ROSE questionnaire (Sjoberg and Schreiner, 2005). In Sjoberg and Schreiner's report of students' responses to the ROSE questionnaire, students from Malawi appear to score higher than students from other developing countries. The students from Malawi seem to have responded to the ROSE questionnaire on the basis of the 'right' answers rather than what is true about them. Further incidence of desirability bias among students has been reported in Case (2004). Case, in her research in South Africa, reports that "most students have learned to recognise the 'right' answers in an inventory" such as a questionnaire (Case, 2004, p. 108). Case points out that the presence of desirability bias among the students casts doubt on the use of questionnaires to determine students conceptions and their approaches to learning. To overcome this problem, the questionnaire was modified so that except for self-efficacy items, students were asked to indicate their feelings on some condition or phenomena rather than on what they felt or do. Instead of asking students the extent to which they memorise facts given by the teacher in a lesson, I asked them the extent to which they looked for facts given by the teacher. Looking for facts given by the teacher is suggestive of memorisation as a learning strategy. Similarly, instead of asking students to indicate the extent to which they consider themselves to be slow in their learning, the students were asked to indicate the extent in which they agreed or disagreed with the statement "Slow learners cannot succeed in learning physical science". In this manner the desirability bias problem was minimised. A copy of the final questionnaire that was used in the study is available at Appendix B. Table 6.2 below presents the sources of the items used in the questionnaire.

Table 6.3 Items used in the questionnaire and their sources

No.	Item	Source
1	Slow learners cannot succeed in learning physical science	Present study
2	Most words have one meaning	Schommer, Crouse & Rhodes (1992)
3	Facts of science do not change	Schommer & Walker (1995)
4	Scientists can get to the truth if they keep on trying	Schommer, Crouse & Rhodes (1992)
5	Knowledge is isolated facts	Schommer & Walker (1995)
6	The best way to learn is to memorise	Present study
7	You cannot do well without ability	Present study
8	Scientists are born with ability to do science	
9	The textbook contains all physical science I need to know for the rest of my life	Schommer-Aikins, Wei-Cheng, Bookhart and Hutter (2000)
10	Science is a description of reality	Present study

11	Ability to learn is fixed at birth	Derived from Schommer *et al*. (1992)
12	When learning physical science I look for facts given by the teacher	Derived from Schommer (1990)
13	Successful students take a short time to learn things	Derived from Schommer (1990)
14	You will get confused if you combine new ideas with old ideas	Derived from Schommer-Aikins *et al*. (2000)
15	Amost all the information you can learn from a textbook you will get during the first reading	Schommer, Crouse and Rhodes (1992)
16	Successful students do not have to work hard to succeed in learning	Schommer (1990)
17	I am certain that I understand ideas presented in physical science lessons	Present study
18	Scientific knowledge changes	Present study
19	Science is sufficiently challenging to me	Present study
20	Working hard pays off only for good students	Derived frm Schommer (1990)
21	Trying hard may result in getting confused	Schommer (1990)
22	Successful students learn by heart	Present study
23	Every student can do well	Present study
24	Those who fail examinations are lazy	Present study
25	I am satisfied with my learning skills	Present study
26	I can do the exercises in the textbook	Present study
27	Only gifted students can succeed in learning difficult learning tasks	Derived from Schommer, Crouse and Rhodes (1992)
28	What you learn depends on teachers	Derived from Schommer *et al*. (1992)
29	I do sufficient work in my studies	Present study
30	I can do well in science at university level	Presnt study
31	Only students with ability do well in science	Derived from Schommer (1990)

The draft questionnaire was validated by one language and two science education experts who advised modification of the questionnaire to include the free response section that asked students to state what they thought was the main cause of underachievement in science education. As previously stated, the recommendation of the experts was accepted. In view of the strong desirability bias referred to previously, I offered the students complete anonymity and administered the added items as a separate questionnaire. When administering the questionnaire I explained to students that the reason I did not want them to write their names on the questionnaires was to ensure that they would be free to state the truth as they knew it without any fear of being disciplined or exposed. The reliability of the first part of the questionnaire was checked through a test re-test procedure and was found to be .81. At one of the schools the correlation coefficient of the items of the main questionnaire and a terminal test that students had taken was determined and was found to be .3 and significant. Possible explanations for the low correlation coefficients are presented later in chapter 7.

6.6.2 The interview protocol

The interview protocol was developed through a series of pilot studies. The initial interview protocol had five items concerning science and science learning. During the pilot studies the necessity of discussing learning in the context of some science content became evident. Zou (2004) argues that students' epistemological beliefs are different in different content areas. Hammer and Elby (2000, p. 4) illustrate the content knowledge-based character of learning through arguing that although the belief that "knowledge is tentative" is more sophisticated than that "knowledge is certain", in some contexts in science, however, the more sophisticated beliefs may not hold. Newly discovered knowledge may be considered tentative. That the earth moves around the sun, for instance, cannot be categorised as tentative knowledge. Belief in tentativeness of knowledge helps to maintain an accommodating attitude to paradoxes and surprises in the scientific community, but newly discovered knowledge may be more tentative than knowledge discovered long ago that has been subjected to frequent testing since that time.

In finding out how students learn physical science, I chose to do so in the context of the kinetic theory of matter. The kinetic theory was chosen because according to the present curriculum, it is the first topic that students learning in Form 3. Where students had not covered the kinetic theory of matter in their studies, a suitable theory that the students had covered was identified and used during the interviews. Students were for example, asked "Did you learn the kinetic theory of matter last term? If they answered "yes", they were then asked state what the kinetic theory of matter says. In this manner students' concepts of learning were probed in the context of learning science. The first draft interview protocol is available at Appendix C and the interview protocol that was used in the study is available at Appendix D.

Items of the interview protocol were derived from the literature. Table 6.3 present the sources of the items that were used in the study.

Table 6.4 Items of the interview protocol and their sources

No.	Item	Source
1	What is science to you?	Present study
2	Have you carried out any investigations in physical science this term?	Present study
3	If yes, describe the investigation you have done.	Present study
4	How do you learn physical science after classes?	Present study
5	When you were learning the kinetic theory of matter, what do you think you really learned?	Derived from Rodgers (2002)
6	What helped you in learning the kinetic theory of matter?	Rodgers (2002)
7	What hindered your learning of the kinetic theory of matter?	Rodgers (2002)
8	How do you know that you learned the theory?	Present study
9	Do you know the prescribed books for physical science? If yes, name them.	Present study
10	What is your goal in learning physical science?	Present study
11	Do you find physical science easy or difficult?	Present study
12	What makes physical science easy or difficult to you?	Present study
13	How should science be taught to make it interesting to you?	Present study

6.7 Research procedures used in the study

Some research procedures were used to facilitate smooth operation in the course of carrying out the study. These procedures were: gaining access to the students;

selecting the samples of students for the study and conducting interviews and administering questionnaires in schools. The decisions made in connection with these procedures may have a bearing on the overall conclusions of the study. For this reason it is necessary to present the decisions that were made in the process of choosing and carrying out the research procedures.

6.7.1 Gaining access to the students

In facilitating gaining access to the students in the schools the following considerations were made. Secondary class 2 and 4 in Malawi are examination classes. This means that students in these classes sit for national examinations at the end of the academic year. I reasoned that teachers may consider it a waste of their time to do the study in examination classes given the importance they attach to national examinations. On the other hand, I felt that secondary class one students may have difficulties in communicating to me about science and science learning in English and decided to do the study among secondary class 3 students. In the letter I wrote to the Ministry of Education seeking permission to do the study, a copy of which is available at Appendix E, I indicated that I wanted to do the study in secondary class 3. The response of the Ministry of Education to my letter came after I had made two follow up visits, is available in Appendix F. I then sought the permission of the 6 Divisional Managers of Education as instructed by the Ministry of Education. I made three follow up visits to one Divisional Office before I got a response. Samples of letters of approval from two Divisional Managers are available at Appendix G. In the schools permission to carry out the study was granted by the heads of the schools after presenting them with letters of permission from the Ministry of Education and from the Divisional Managers of Education.

6.7.2 Selecting research samples

The participating schools were selected on stratified random basis from a list of all Government and Government Assisted Schools (GGASS). There were 89 such schools. Eighteen schools were randomly selected from the 89 to participate in the study. Three schools served as pilot schools for trial of the instruments. The total number of secondary class three students in these schools was 14, 627 (Malawi Government, 2000, p. 74). To ensure proportional representation schools were stratified according to gender and ownership before using random process to select the participating schools. The approximate location of the schools is shown in Figure 6.1.

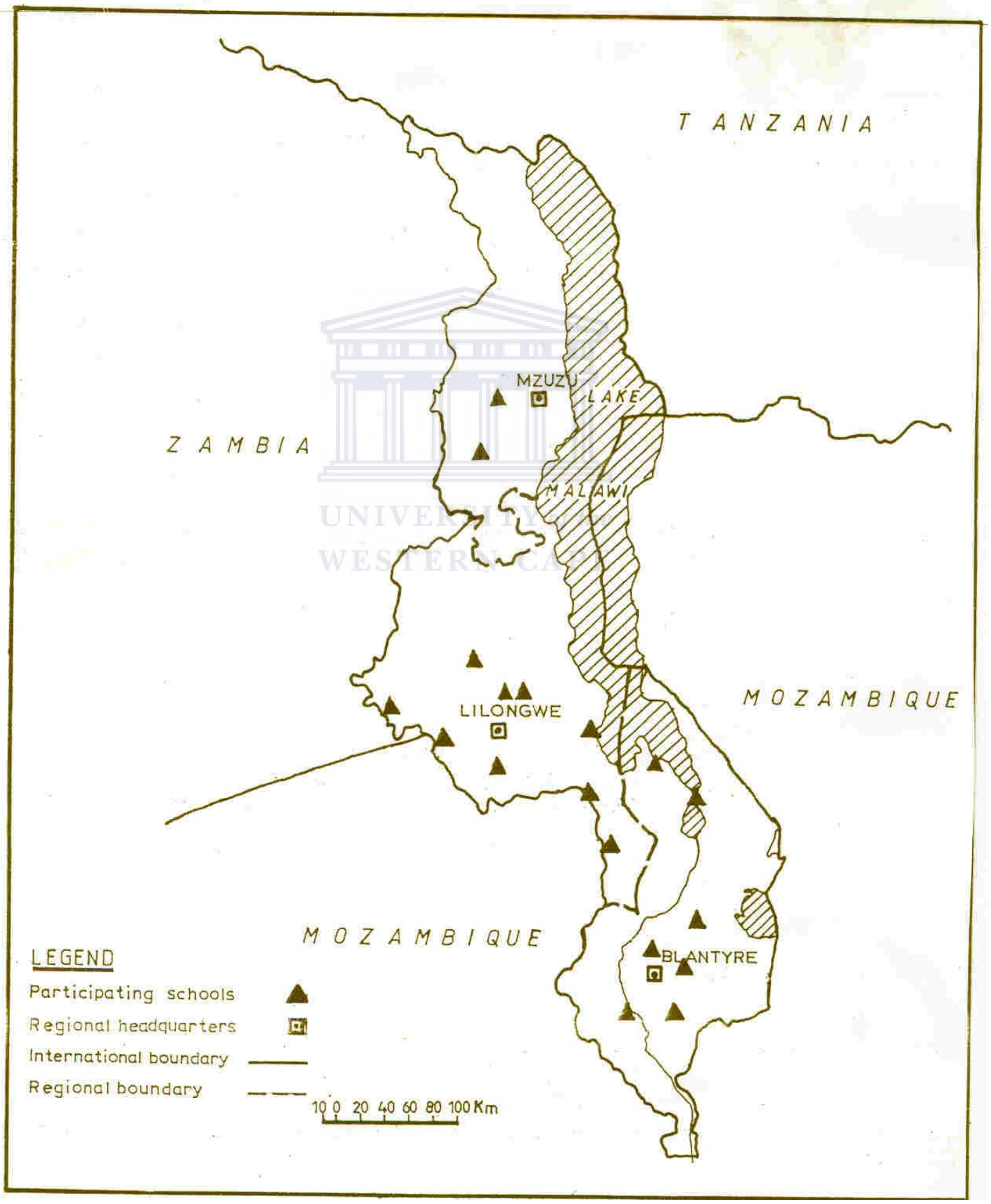

Fig. 6.1 Map of Malawi showing the approximate location of participating schools

In the participating schools all the students that were willing to participate in the study were welcome to complete the questionnaires without communicating with other students. The questionnaires were completed under examination conditions in which students were free to ask for clarification on any item from the researcher but were not allowed to consult each other. Allowing students to consult each other would have lowered the validity of the study. A total of 1,303 students completed the main questionnaire. The anonymous questionnaire was completed by more students, 1, 468 students. The increase in number is a result of students feeling safer with completing the anonymous questionnaire than the main questionnaire.

Interviews were used to find out students' meanings of their resposes to the questionnaire. Many students for instance strongly agreed with the item that stated that one would get confused if they combined new ideas with old ideas. This is an item on the integration knowledge and the students appeared to be saying integration of knowledge would result in people being confused. When students who strongly disagreed with the statement were asked why their colleagues strongly agreed with it, they suggested that their colleagues who agreed with the statement were thinking in terms of Biblical knowledge. The students' hint immediately brought to my mind a verse in the Bible in Deuteronomy 12: 32, in which Jahovah said "What thing soever I command you, observe to do it: thou shalt not add thereto, nor diminish from it" (quoted in Brubacher, 1966, p. 169). Brubacher argues that rote memory learning strategies, as were used in learning the Mosaic Law, discourage any spontaneity of initiative in learning. It seems that some students consider learning of science to be mere memorisation of facts given by the teacher to be kept in the form in which it was presented.

Initially, I planned to use samples of maximum variation when conducting the interviews to gain knowledge of the level of engagement in learning science of the most and least promising students. At the pilot stage I asked class teachers to choose 2 students from the above average, average and below average categories in their classes for participation in the study. It was, however, found that most of the below average students were not able to express themselves fluently in English. In one particular case, a chosen student was not able to speak English. The teachers concerned explained that most of the below average students in their school had not been offered places on merit. In the main study I decided to use the sample that would give me as much information as I needed for the study. I used the best four students (2 boys and 2 girls) as rated by the science teacher in each class. In some schools the best six students (3 boys and 3 girls) were used. The findings of the study are unlikely to be affected by this decision because the study was meant to find out why highly selected students performed poorly science. The students who could not utter a sentence in English had been admitted to the school through other criteria other than merit. Such students would falsify findings of the study if they were included in the sample of students interviewed. This study sought to find what kept the highly selected students in secondary schools from performing in science at their expected levels. Inclusion of students who bypass the selection process would hence lower the validity the findings of the study.

6.7.3 Administering the questionnaires and conducting interviews

Except in one school where the questionnaire and interviews were conducted after classes, data collection in schools took place during normal classes in laboratories, staffrooms, classes or home economics rooms. Administration of the questionnaire started with an explanation of the reasons why the study was being done. Students were told that the ultimate purpose of the study was to improve students' learning of science. It was further explained to the students that the questionnaire was not an examination but an attempt to find out what they felt about the items therein. Students were allowed to ask any question about the items in the course of the administration of the questionnaire. The anonymous questionnaire was administered after completion of the main questionnaire. In debriefing sessions after the administration of the questionnaires, I explained the purpose of every item of the questionnaires to the students.

Like administration of the questionnaires, interviews started with explaining to the students the purpose of the study and its importance in science education in the country. First questions during the interview were meant to pacify the students and were not recorded. The interviews ended with a debriefing session that was also not recorded. The purpose of the debriefing sessions was put the student or students at ease and to assure them about the confidentiality of the study. A sample of an unedited interview transcript is available at Appendix H.

6.8. Data analysis

Given the multi-method nature of the study, various methods of data analysis were used to derive some meaning from the data and answer the research questions. The methods of data analysis used were document analysis, obtaining descriptive statistics, inductive and interpretive analysis of interview transcripts and free response questions. These methods are discussed next seriatim.

6.8.1 Document analysis

Documents pertaining to education and science education were classified into "intentional documents" and "unpremeditated documents" following Borg and Gall (1989) and London (2001). Unpremeditated documents are those that were prepared to serve an immediate purpose such correspondence that followed Huxley's report that was kept in the Department of Education. The people who wrote these letters had no knowledge that their letters would be used for historical purposes. They freely expressed their ideas about the consequences of teaching science to Africans. One weakness of unpremeditated documents is that sometimes they reflect personal opinion. Another example of premeditated documents is the communication between officers in the department of education written in minutes in official files. The officers who wrote these minutes did not know that what they were writing would be used for historical purposes. The Annual Reports of the Department of Education, however, are intentional documents. Similarly, minutes of the Advisory Council of Education in Nyasaland are intentional documents because their purpose was to record the institutional history of the committee. Intentional documents tend to be doctored to serve the purposes of the writer rather than to portray an unbiased picture of an event. Both types of document were used in this study. Issues pertaining to science education were during the analysis followed up from the Colonial Office to the colonies and back to the Colonial Office.

Other historical sources were also consulted so as to compare results of two or more researchers as suggested by Strydom and Delport (2002). The story of introduction of biology as a school subject derived from documents found in the National Archives in Malawi was compared with Sivonen's (1995) portrayal of the same story. Sivonen drew his story from sources in the Colonial Office in London. In this manner the correctness of my interpretation of the historical events was checked and enhanced.

6.8.2 Descriptive statistics

The SPSS for Windows up to version 11 software (Pallant, 2001) was used to obtain descriptive statistics from the survey data collected. The variables in the data were coded as indicated in Pallant (2001) and Field (2000), before the data were entered. The data were then entered and cleaned using the procedures for checking for errors, checking categorical variables and continuous variables described by Pallant (2001). The means, standard deviation and variance of each item were obtained. The items were then arranged in order of decreasing mean and variance.

The questionnaire was constructed at the beginning of the study. In the course of the study some research questions such as one concerning the work that students actually do in a term, have had to be dropped because changes in science policy made it impossible to assess students' work in this connection. The items that have not been included in the tables in chapter 7 were not the focus of the study at the time I did the analysis.

6.8.3 Analysis of items of the anonymous questionnaire

There were two items on the anonymous part of the questionnaire. One item asked the students to indicate the grade they think they would achieve in each subject in the School Certificate Examinations. This item was measuring students' academic self perception. The other item asked the students to state the greatest obstacle to their doing very well in School Certificate Examination in physical science. Students' attributions of their success or failure were the focus of the second item. These items were analysed differently as indicated in the following paragraphs.

Academic self-efficacy

Tally tables for grades 1 to 9 (Candidates are graded on a scale of 1 to 9 where 1 is the highest grade and 9 is the lowest grade) for four subjects; physical science, mathematics, biology and English for each school were made. The tally tables were converted into histograms. Such histograms for four schools were compared. The numbers of students who expected to achieve the same grade were added across the 16 schools for each of the four subjects. Average percentages of students scoring each grade over the past 5 years, 1999-2003 were obtained from the Malawi National Examinations Board (MANEB) and compared with students' aspired grades to determine the gap, if any, between students' expected grades and Examination Board average grades. I assumed that the examination grades were unlikely to change significantly in short future from the average grades over a period of five years.

Attributions of failure

The technique of inductive analysis was used to analyse students' attributions of failure in national examinations. The processes of unitizing and categorising

(Rudestam and Newton, 1992) were used. Unitizing is a coding operation that identifies information units relevant to a given theme in a text. In the categorising process units of information realised in the unitizing process are organised into groups called categories on the basis of similarity in meaning. The inductive analysis technique was applied to the attributions item and the results are presented in chapter 7.

In the actual analysis of data of the anonymous questionnaire, students' responses to items of the free response questionnaire were read through in the while in the field, without marking anything on them. Commonly used meaning units that contain one idea emerged from the students' responses. For instance, students attributed their failure in national examinations in physical science to teachers. The teachers were considered by the students to be lazy, unqualified, in short supply or ineffective in their teaching. Codes were developed for each category of teachers. Similarly codes were developed for other factors that students thought affected their performance in national examinations such as absence of science textbooks and inadequate supply of science learning apparatus.

During the final reading of the students' responses to the items of the questionnaire, the codes that I developed were used to indicate corresponding units of meaning implied by particular students' responses. For example, where a student said students fail physical science because physical science as a subject is difficult, the code "subjectdif" was written in red pen on the right hand margin against the student's statement. Each unit of meaning found in students' responses was coded in this manner. Telling quotes for use during the reporting stage of the study were identified and marked with a red star for easy identification. The codes were subsequently tallied across all questionnaires to determine student's weightings of the various factors.

6.8.4 Analysis of interview data

The interview data was used in the study to investigate students' conceptions of science and science learning and, to determine the extent to which the students regulate their studies. In general analysis of interview data took the form of inductive and interpretive analysis (Hatch, 2002). Statements pertaining to some theme such as science learning were culled from the interview transcripts and were put into categories. The process of unitizing and categorizing units of information culled from the interview transcripts was used to extract meaning from the data (Spradley cited in Hatch, 2002). The manner in which the interview data were analysed to yield information on students' conceptions of science and science learning and, on students' self-regulatory practices if any is discussed in chapter 7.

In analysing interview data, transcripts were read several times to identify units of meaning in students' responses to items on the interview protocol. Students' responses to each item on the interview protocol were coded as in the case of the anonymous questionnaire. The coded statements that were related to a particular research theme were subsequently extracted from the transcripts and written on fresh pages. The statements were then classified into categories. The frequency of occurrence of each category in the interview data was determined.

Conceptions of learning science

In view of the strong desirability bias among the students, I decided to ask the students to tell me what they do when they study on their own and to derive students' conceptions of learning from what they do when they study on their own. The conceptions of learning were coded and categorized. The categories that emerged from the analysis are presented in chapter 7.

6.9 Reliability and validity of the study

The purpose of this section is to discuss the measures that were taken to ensure credibility and trustworthiness of the findings of this study. Since the study used both quantitative and qualitative methods of data collection and analysis this section is divided into two parts. Reliability and validity issues pertaining to the qualitative part of the study are discusses first.

6.9.1 Reliability and validity of qualitative aspect of study

As Ary, Jacobs and Razavieh (2002) maintain issues of reliability and validity are important in both qualitative and quantitative research. Researchers get concerned with validity of their findings or constructs when they wonder whether their findings, conclusions or constructs reflect the thing or construct they set out to investigate. Similarly researchers grapple with issues of reliability when they speculate whether other researchers would arrive at the same interpretation or construct if they did the same study in similar circumstances. The literature suggests various ways of enhancing the validity and reliability of qualitative research (Macmillan and Schumacher, 2001; Merriam, 1998; Ely, Anzul, Friedman, Garner and Steinmetz, 1991). Lincoln and Guba (1985) list the things that a researcher should do to increase the likelihood of ending up with credible and trustworthy findings. These authors recommend that to promote the credibility and trustworthiness of qualitative research, researchers should: have prolonged and persistent engagement in the field; triangulate method and analysis; search for negative examples; determine referential adequacy; experience peer debriefing; and, check their interpretation with participants. In the following paragraphs I discuss what I did to ensure credibility and trustworthiness of the conclusions of this study in terms of Lincoln and Guba's (1985) criteria.

Engagement in field work

From 2002 to 2006, I have been engaged in collecting and analysing data for this study. The study of archives started in 2002 and has continued throughout the duration of the study period. The archival documents have been read several times each time deriving more insight about the problem. When, for instance, I learned about failure of Malawian students to get admitted to Makerere College, I regarded this as evidence that science and mathematics were a problem to Malawian students.

After reading Chipembere's (2000) autobiography where he writes about traditions established by the colonial regime that persist many years afterwards even after change of rulers, however, I decided to re-read all the Department of Education Annual Reports from 1942 to 1950 to identify the traditions that Chipembere refers to. I present my experiences in trying to identify the traditions that have led to poor performance in science and mathematics below.

A close examination of the annual reports suggests that the missionaries and colonial administrators settled for poor performance among students in Malawi. They apparently made no effort to improve students' performance in Makerere Examinations. In 1942 the Principal of Blantyre Secondary School confirmed the assessment of Makerere Examiners that his students were poor in science and mathematics. In 1943 all the 7 candidates from Nyasaland who sat for the Makerere Entrance Examination failed. In following year Blantyre Secondary School reported that Makerere Entrance Examination was too much for its candidate. The report goes on to say that "it seems clear that our next step should be to develop a full secondary course with a view to entrance to a higher college or some other form of vocational training" (Dep. Ed. Rep., 1944, p. 6). The argument here is that because Makerere Examinations were too difficult for Nyasaland students, higher secondary courses should be introduced so that Nyasaland students could go to a higher college than Makerere. In the same year Zomba Catholic Secondary School reported that three of its students attempted Makerere Entrance Examination and "proved definitely that Nyasaland pupils have not yet attained that standard" (Dep. Ed. Rep. 1944, p. 6). In 1945, again all candidates for Makerere Entrance Examination at Zomba Catholic failed. The 1948 Department of Education Report portrays contempt for Makerere College. The report reads:

> The two Standard X boys attempted the Makerere College Entrance Examination and both failed. It must be confessed that they were not really interested in this Examination and did not relish the prospect, if they were

> successful, of spending four or five years working for a diploma outside the protectorate (Dep. Ed. Rep., 1948, p. 11).

In the early years of Makerere Entrance Examinations the reason given for the failure of students from Nyasaland was that the examination was prepared for Standard X students and not for Standard VIII students. The letter of the Acting Principal of Makerere College dated 15th June 1938, however, indicates that Makerere College admitted students with Junior Secondary Leaving Certificate (Acting Principal of Makerere College, 1938). The excerpt above suggests that even Standard X students from Nyasaland could not pass the Makerere Entrance Examination. Instead of putting down measures to improve the performance of students, the missionaries and colonial administrators sought to discredit and abandon Makerere as a possibility for higher education for students from Nyasaland. In his report on a visit to Uganda where he gave evidence before the Commission on Makerere College, Lacey the then Director of Education wrote "Makerere must not be allowed to deviate secondary schools in Nyasaland from their purposes" (Lacey, 1937, p. 6). The story of Makerere Entrance Examination resembles the abandonment of physical science as a school subject on account of its being difficult for students in the country that happened in 2003 as indicated previously. To this day students in Malawi do not appear to have reached the Makerere standard, hence Chipembere's (2001) reference to traditions that continue to affect students even after change of rulers. This issue has been presented in detail to show that I have been persistent in my efforts to understand the nature of the problem of poor performance in science and the factors that brought it about.

Triangulation

Triangulation is the process of using several research methodologies in the study of the same phenomenon (1997). Schostak (2002) maintains that triangulation performs two main functions in qualitative research: coordinating the attention of individuals to produce a shared reality; and, providing a means of cross-checking data and findings.

In Schostak's analysis interviewing subjects, amounts to trying to see the object of investigation from the perspectives of the interviewees. In this connection this study interviewed 40 students drawn from 15 schools on the topic of science and science learning. The students enable me to see science and learning from their perspectives.

The cross-checking function of triangulation was realised in the study through the use qualitative and quantitative research methods in collecting and analysing data. Data about the same phenomenon collected by different methods were compared to determine its credibility and trustworthiness. Data on self-efficacy for instance was collected in three ways: Likert scale items, interview questions and a free response item. The data was analysed differently but the results were compared. Similarly data about the nature of science was collected through two different questions on the interview protocol and the two items on the Likert scale questionnaire.

6.9.2 Other measures taken to ensure validity and reliability of the study

The test-retest coefficient of reliability of the learning beliefs and practices questionnaire was determined and was found to be .8, seven days elapsed before the second testing. The construct validity of the items was reviewed by three experts who recommended inclusion of the anonymous questionnaire. The coding of students' responses to the anonymous questionnaire was checked through independent coding of a sample of 50 questionnaires by a language expert. The agreement between my coding and that of the language expert was 96%.

The correlation between the items of the learning beliefs and practices questionnaire and one school's terminal test in physical science was determined and was found to be 0.3 and significant. Other researchers such as Kellaghan and Greaney (2004) have found at the primary school level similar low correlation between examinations and learning assessments. According to these authors:

> In Malawi, close to four out of five pupils passed the Primary Certificate Examination, but in a national assessment, only one in five achieved minimum mastery (Kellahan and Greaney, 2004, p. 38).

It seems that students in Malawi learn the skills that enable them to do well in examinations but perform poorly in tests concerning learning skills and mastery of material learned.

6.10. Ethical issues

Ethical issues were given their due consideration in this study. As Schostak (2002) and Cohen et al (2000) assert, breaking into individual psyches of students and making public their private ideas and states of understanding of some phenomena is inevitably going to cause some disturbance in the lives of the students and their teachers. Webster cited in Schostak (2002) maintains that words are not, as is sometimes claimed, neutral, harmless instruments. Words, in Webster's analysis can be as almost as lethal as bullets and "can cause great offence and personal distress" (Webster quoted in Schostak, 2002, p. 180). I was aware of the possibility of causing unnecessary harm or distress among the students and teachers while doing this study and I was committed to reducing the effects of any such harm or distress among the participants. Consideration of ethical issues in this study was guided by the Belmont Report. This report is briefly discussed next.

The Belmont Report summarizes basic ethical principles that were identified by the National Commission for the Protection of Human Subjects of Biomedical and Behavioural Research (The National Commission for the Protection of Human Subjects of Biomedical and Behavioural Research, 1979; Polit, Beck and Hungler, 2001). The Belmont Report was adopted as a guideline for this study because it is recommended by the Research and Publications Committee in the University of Malawi. The report articulates three main principles on which standards of ethical conduct in research should be based, namely: respect for persons; beneficence; and, justice. Measures taken to protect the rights of students are discussed below under these three principles.

6.10.1 Respect for persons

The principle of respect for persons acknowledges the right to self-determination and the right to full disclosure. In this study permission to do the study was obtained, as previously stated, from the Ministry of Education, the Divisional Education Managers and from the head teachers of the participating schools. The permission granted by the various offices was not considered to be a right of access to the students. The students were treated as autonomous agents. Their participation in the study was negotiated with the students themselves. The participating students were told that they were free not to take part in the study. The purpose of the study was explained to them and they were allowed to ask any questions about it. Some of the participants refused to hand in their partially completed questionnaires and I allowed them to keep them. Students were assured about the confidentiality of all the data from this study. Students were further assured that the data from this study will be used for research purposes only. Anonymity of the participants was enhanced by asking students to refrain from writing their names on the second questionnaire that involved very sensitive information. The rights of the students to self-determination and full disclosure were thus observed although full disclosure was possible only after the students had been interviewed or had completed the questionnaire. It was necessary to withhold some information about the study until the students had been interviewed or had completed the questionnaire. As Kvale (1996, p. 113) maintains, in some interview investigations it is prudent to withhold the specific purpose of the study until interviewees natural views on a topic have been obtained "to avoid leading them to specific answers". For instance, it would have been unwise to talk about the nature of science or science learning before the students had been interviewed or before they had completed the questionnaires. In the debriefing sessions, however, full disclosure was achieved.

6.10.2 Beneficence

The principle of beneficence requires the researcher not only to protect persons from harm but also to secure their well-being. Making students aware of the state of their understanding of conceptions of science and science learning was upsetting experience to many students who initially thought they had a good grasp of these concepts. Similarly some students felt distressed when they discovered that there was much that they could do improve their learning of physical science. This study adopted the principle that students should not leave the research situation with "greater anxiety or lower levels of self-esteem than they came with" (Cohen *et al*., 2000, p. 64). The study included a general debriefing session in which the participating students were informed about the various possibilities in science learning and the nature of science was explained to them. The students were in the debriefing session urged to assume responsibility for their learning.

In one participating school, teachers asked me to talk to their secondary class 4 students in the same manner that I had spoken to their secondary class 3 students. At another school, after explaining to the head teacher about the purpose of the study, the head teacher on his own initiative, arranged for staff meeting after classes during which he asked me to talk to the staff members about my study. The staff members agreed that they had done little to improve students' learning skills and further agreed to find ways of assisting students in learning. One of the staff members said that at the secondary school she went to, one of the teachers was asked to give first year students a talk on how to learn. At yet another school, the students who participated in the study in the previous year came out of their class to thank me for what I had said to them during a debriefing session, when I visited in the the school on another business the following year. These incidences indicate that the principle of beneficence was observed in this study.

6.10.3 Justice

The principle of justice involves fair distribution of befits and burdens in the course of doing research. Hatch (2002) suggests that a researcher should at the design stage of a study determine how the participants are going to benefit from taking part in the study. In this study the participants benefited from being given a talk on how to learn physical science during the debriefing sessions.

6.11 Demarcation of the thesis

Many studies have investigated the problem of poor performance in science in Malawi. Some such studies, such as Mbano (2003) have sought to establish causal relationships between factors such as reasoning skills and performance in science. The point of departure of this study is the realization that the results of these studies have been inconsistent. Recommendations made in them have not resulted in improvement in the general performance of students in the past. As I have indicated in chapter one of this study, studies done so far, have had no explanation for better performance in science among Tanzanian students compared to Malawian students that Chipembere (2000) observed. I concluded after reviewing extant studies on the problem of poor perfornce in science in Malawi that previous studies worked on some dimensions of a complex problem whose identity and origin were still unknown.

The aim of this study was twofold: to identify the origins of the problem of poor performance in science and to investigate the manner in which the problem affects students' learning of science today. Assuming a constructivist view of learning, the study investigated students' conceptions of science and science learning in addition analyzing archival documents. In doing this, the study did not seek to determine causes of poor performance in science. The study does not seek to examine or identify causal relations. Causes of things are normally established through experimental studies and not through interviews and surveys. Knowledge claims of this study are insights into the nature of the problem and the manner in which it may be alleviated. In the next chapter results of the study are presented and discussed.

Chapter seven

Results: Presentation and Discussion

7. Introduction

In this chapter the results of analysis of documents and data collected through questionnaires and interviews, are presented and discussed. The chapter opens with a description of the actual sample and its characteristics. Then follow findings and discussions thereof. The chapter ends with a summary of the main findings.

7.1 Actual sample and its characteristics

The main realised sample consisted of 1,303 secondary class 3 students (725 boys and 578 girls) drawn from 16 schools that were randomly selected from 89 Government and Government Assisted Secondary Schools (GGASS) in Malawi. The mean age of the participants was 17.1 years. Their maximum and minimum ages were 23 and 13 respectively. The main sample completed the learning beliefs and practices questionnaire. All the students in the main sample and 165 additional students drawn from the participating schools completed the anonymous questionnaire. A further sample of 40 students drawn from the main sample was interviewed. What follows are results of the analysis of archival documents, questionnaires and interviews.

The presentation is organised according to the research questions. The findings pertaining to the first research question are presented first. Findings about the other research questions follow one after another.

7.2 Research question 1: How have students performed in science subjects in national examinations in the past?

There is little doubt that performance of students in science subjects in Malawi has been poor. All the documents available indicate that Malawian students have been performing poorly in science subjects. To substantiate this finding I collected examination results data for physical science, mathematics biology and agriculture from the Malawi National Examinations Board. Grades awarded to students range from 1 to 9 where 1 denotes the best grade and 9 denotes a failure grade. I divided the grades into 3 groups following usual classification in nine point scales: 1 to 6 representing credit passes; 7 and 8 representing bare passes and, 9 representing failure. I then calculated the percentages of students achieving the various categories of grades from 1984 to 1993 and drew a histogram to determine trends. Figure 7.1 shows that the performance of students in physical science was not only poor but it was also deteriorating.

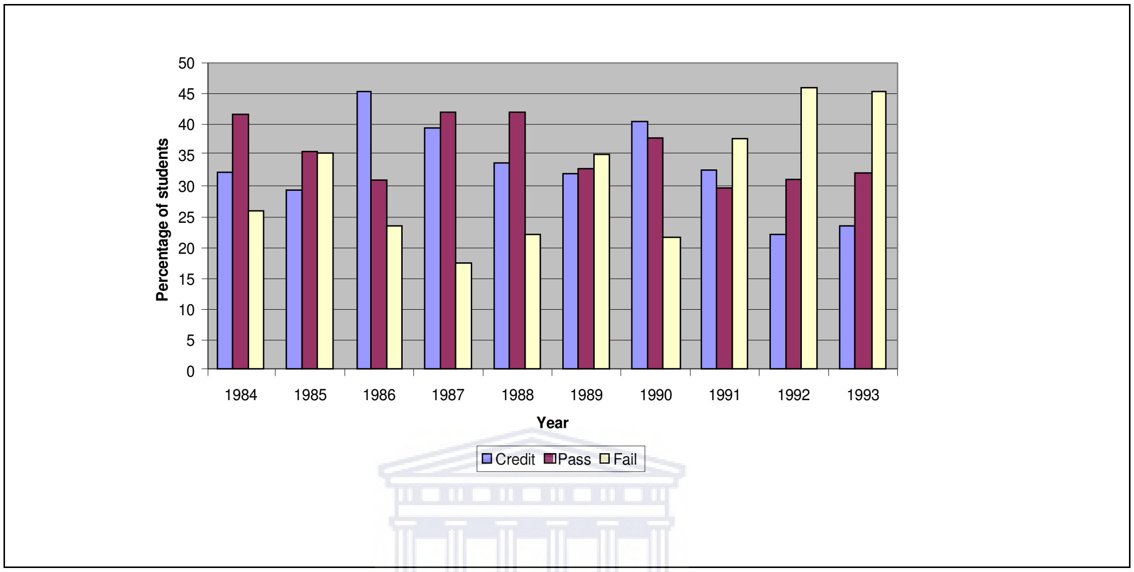

Fig. 7.1 Percentages of students achieving credit pass, bare pass and failure grade in physical science from 1984 to 1993

In university selection processes in Malawi grades 7, 8, and 9 are taken to be failure grades. This means in every year between 1984 and 1993 over 50% of the candidates failed to qualify for entrance into universities in the faculties of science. These candidates, however, are not ordinary students they are the cream of a nation. It is hence worrisome that such highly selected students perform in science and other subjects below their expected levels. Although there was a slight imporovement in students' credit passes in 1990, credit passes deteriorated in the following years. Deterioration in the performance of students is portrayed in Fig. 7.1 through decreasing percentages of credit passes and increasing percentages of students being awarded the pass and failure grades from 1986 to 1993.

The 1984 to 1993 data was averaged and used to compare students' performance in physical science with their performance in mathematics, biology, and English and Figure 7.2 was the result.

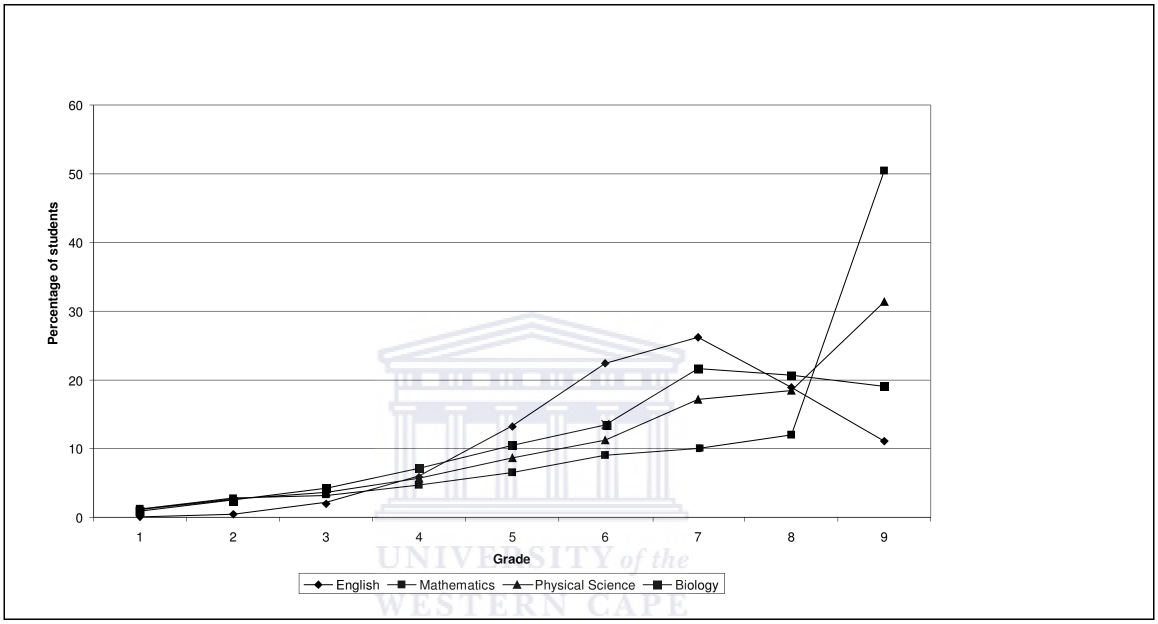

Fig. 7.2 Average performance of students in English, physical science, biology and mathematics from 1984 to 1993

As indicated in the graph in Fig 7.2 mathematics and physical science stand out as subjects in which students perform most poorly. More recent data on performance of the students indicates that the trends portrayed in Fig 7.2 have worsened over the years. Percentages of students who achieved various grades in physical science, mathematics, biology and agriculture from 1999 to 2003 were obtained from the Malawi National Examinations Board. A comparison of students' performance in physical science, mathematics, agriculture and biology yielded the histogram in Fig. 7.3. The similarity between Fig. 7.2 and 7.3 suggests that little change has taken place in the performance of the students since 1984. The Average failure rate in physical science, increased from 31% between 1984 and 1993 to 41% between 1999 and 2003. In Mathematis the average failure rates increased from about 50% in the period 1984 to 1993, to about 62% in the period 1999 to 2003.

Fig. 7.3 Average percentages of students achieving grades 1 to 9 in physical science, mathematics biology and agriculture from 1999 to 2003

The predominance of the failure grade indicates that the performance of students has tended to worsen with time. These graphs and histograms beg the question of what could have gone wrong with the students. Variables that affect students' achievement are numerous. Previous studies have investigated variables such as teachers, availability of resources, level of cognitive development and students'attitudes to science. The constructivist perspectives on learning and the multi-dimensional concept of learning that inform this study suggest variable that are known to affect students' achievement in the literature but have not been investigated in Malawi. These variables are: self-efficacy beliefs; epistemological beliefs about science and science learning, students' learning skills and students attributions of success or failure. The study explored these beliefs and attributions of failure to determine their possible roles in the performance of the students. The next section presents findings of students' self-efficacy beliefs about learning science.

7.3 Research question 2: What perceptions of themselves, as learners of science, do the students have?

The students have high positive perceptions of themselves as learners of science.

In view of the strong desirability bias among the students that has been refered to in the preceding chapter three different methods were used to assess the self-efficacy beliefs of the students. The methods used were: students' prediction of the grades they are likely to achieve in the examinations in the following year; students' responses to self-efficacy items in the questionnaires and interviews. My findings about self efficacy are presented in the following paragraphs.

7.3.1 Predicted MSCE grades

Participating students were requested to predict the grades they were likely to achieve in the MSCE in various subjects in the following year. The predicted grades of one school were compared with those of other schools. The average predicted grades for all the students participating in the study, in physical science were compared with the average achieved grades from 1999 to 2003. The results are presented in three parts namely: school to school comparison of predicted grades; cross curricular comparison of predicted grades and comparison of average achieved grades from 1999 to 2003, to total predicted grades. Results of self efficacy assessment derived from students' responses to relevant items in the questionnaire and interview protocol are presented last.

Inter-school comparison of predicted grades

The most important finding about inter-school comparison of predicted grades was that these grades varied from school to school. In one school students appear to consider certain grades beyond their abilities while in other schools no grade appears to be beyond students' abilities. Figures 7.4 (a) and (b) portray differences in students' self-assessments of their abilities.

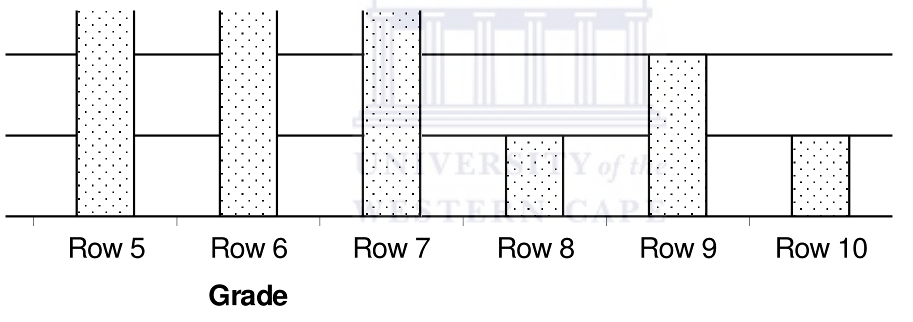

Fig. 7.4 (a). Percentages of students who predicted achievement of indicated grades in physical science in the MSCE examinations in the following year, school (a), N=42

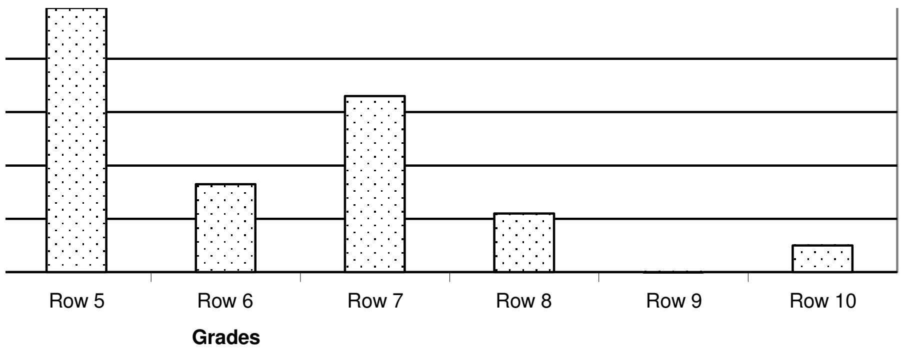

Fig. 7.4 (b). Percentages of students who predicted achievement of indicated grades in the MSCE examination in physical science in the following year,school (b), N = 91.

It is note worthy that there were no students in school (a) who expected to achieve grade 1 although in school (b) more that 20% of the students were expecting to achieve that grade. Since participating schools were all GGASS, they enroll students of about the same socio-economic status and are eaqually provided for in terms of school equipment. The differences in their perception of their abilities may lie in school-related factors. This observation points to the possibility that the schools themselves have ways of communicating to the students what is achievable in the school. In similar vein Fig. 7.5 (a) and (b) portrays students' expectations that suggest existence of school based determinants of performance in physical science if all the other factors are assumed constant.

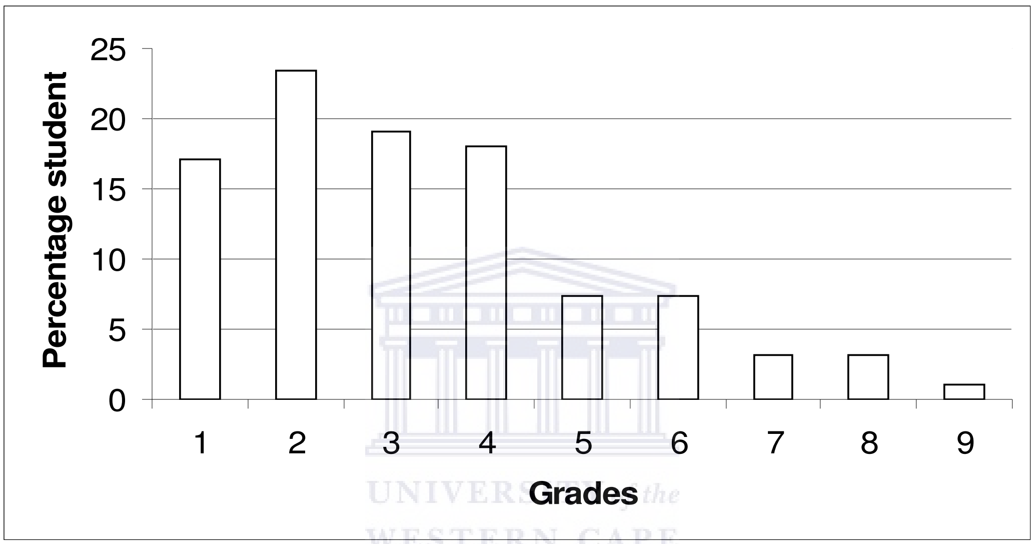

Fig. 7.5 (a). Percentages of students expecting to achieve indicated grades in the MSCE examination in physical science in the following year in school (c), N = 94

Fig. 7.5 (b). Percentages of students expecting to achieve indicated grades in the MSCE examination in physical science in the following year in school (d), N = 66

Like in figures 7.4 (a) and (b) there are conspicuous variations in the numbers of students who think they have what it takes to achieve grade 1 in the schools in Figures 7.5 (a) and (b). As Bandura (1997, p. 3) states, students have to be convinced that "they have what it takes to succeed" if they are to succeed in the face of adversity and try again in the event of failure. Predicted grades in physical science were compared with similar grades in mathematics, biology and English. The results of the inter-subject comparison of predicted grades are presented next.

Inter-subject comparison of predicted grades

Students' predicted grades in four subjects were compared to explore their perceptions of their self-efficacy in the subjects. The subjects involved were physical science, mathematics, biology and English. English was included because in the past Malawian students have done better in this subject than in mathematics and science. Figure 7.6 portrays the results of the comparison of predicted grades in the selected su

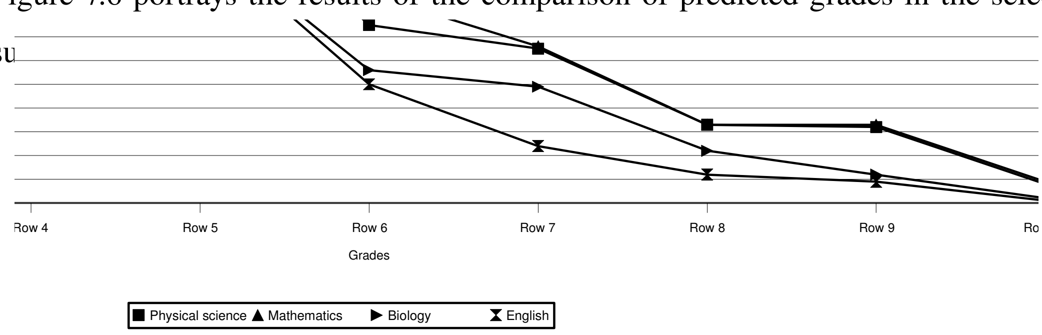

Fig. 7.6. Comparison of predicted grades in four subjects: physical science mathematics, biology and English

Figure 7.8, suggest that physical science and mathematics are perceived to be the most difficult subjects and English and biology are comparably the easiest subjects. As depicted in Fig. 7.8 the English curve rises above the other curves in 1 to 4 region but falls below the other curves inm the 5 to 9 region of the graph. This implies that more credit grades and less pass and failure grades were predicted for English than for the other subjects.

When average performance in physical science between 1999 and 2003 is compared with students' predicted grades, the result are the two graphs in Figure 7.7 each of which looks like a mirror image of the other.

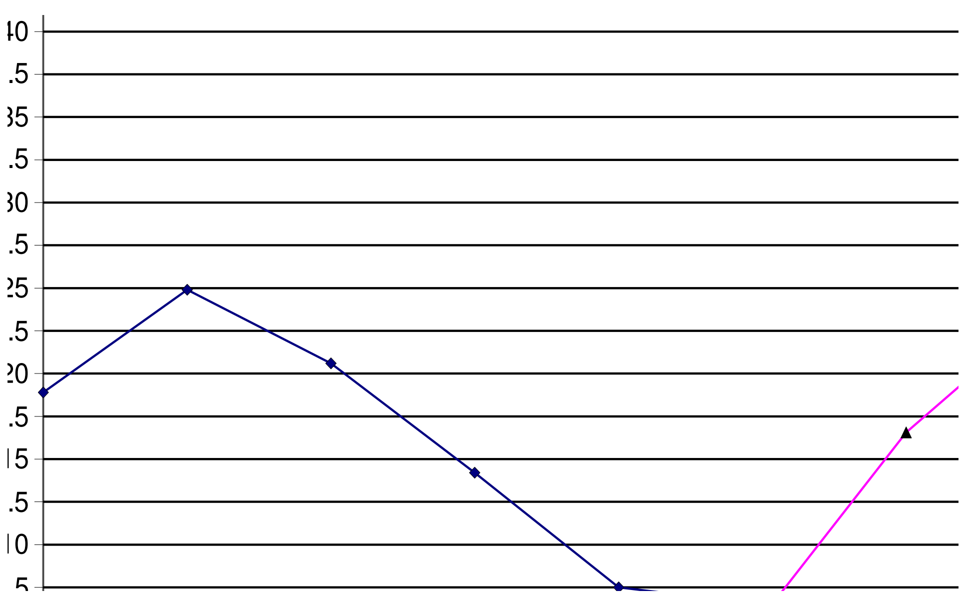

Figure 7.7 Comparison of predicted grades and average 1999 to 2003 achieved grades in physical science

The reality of results in the national examinations in physical science does not appear to affect students' assessments of their possible achievements. In some schools students were not even aware of performance of the students who sat for the examination in their schools in the previous year. It seems correct to say that the students did not take into account performance of candidates in the physical science in the past years in predicting their grades. Students' responses to seven items in the questionnaire that measured their self-efficacy indicate that they have high academic self-efficacy beliefs as shown in the Table 7.1 below. A five point Likert scale ranging from strongly disagree (1) to strongly agree (5) was used.

Table 7.1 Descriptive statistics of students' scores on self-efficacy items of the questionnaire.

Item	N	Mean score	Standard deviation
I do sufficient work in physical science to succeed in the subject	1282	3.98	1.0
Every student can do very well in physical science	1279	3.90	1.1
I am certain that I understand ideas taught in physical science	1286	3.81	1.1
I am sure, I can do very well in solving problems and doing exercises in the physical science books	1296	3.80	1.1
I can do very well in physics and chemistry at university level	1282	3.75	1.3
My work in physical science is sufficiently challenging to enable me to learn the subject	1292	3.66	1.2
I am satisfied with the learning skills I use in learning physical science	1288	3.48	1.3

The reliability coefficient of the items in the table above was 0.58. The general direction of the findings in table 7.1 above were checked through an item on the interview protocol that asked students to state whether they find physical science easy or difficult. Sixteen out of the 22 students who were asked this question stated that physical science was an easy subject to them. Only three students stated that they found physical science difficult. The remaining three claimed that the subject was sometimes easy and sometimes difficult depending on the quality of teaching.

The answer to the second research question about students' perceptions of their ability as learners of physical science is that the students have very high academic self-efficacy. All the methods used to determine students' self-efficacy indicate that the students have confidence in their ability to learn physical science successfully. All the scores on self-efficacy items in the questionnaire were above 3 and except for one item, all were close to 4. This indicates high perceptions of self-efficacy among the students. The majority of the students therefore appear to think that they have what it takes to succeed in physical science. Self-efficacy alone, however, would not ensure success of students in their learning. The science education literature emphasizes the role of epistemological beliefs to which I turn in the next section.

7.4 Research question 3: What epistemological beliefs about science and science learning do the students have?

The results indicate that the students have positivistic or empiricist beliefs about science and science learning.

The learning beliefs and practices questionnaire was used to determine students' beliefs about knowledge, learning and science that the students hold. In the interviews one question about science was asked. Students' responses to the questionnaire and interviews were analyzed as indicated in the previous chapter and the results are presented below. For the sake of convenience epistemological beliefs are divided into three units namely: learning-related beliefs; ability related beliefs and nature of science-related beliefs.

7.4.1 Learning-related beliefs

Table 7.3 below shows descriptive statistics of learning related items of the beliefs and practices questionnaire arranged in order of decreasing mean score.

Table 7.2 Descriptive statistics of the learning-related questionnaire items

Item	N	Mean score	Standard Deviation
1. Scientists can get to the truth if they just keep searching for it	1292	4.1	1.0
2. Successful students of physical science take a short time to learning anything in the subject.	1294	3.90	2.0
3. When learning physical science I look for facts given by the teacher.	1292	3.80	1.1
4. Slow learners cannot succeed in learning physical science.	1293	3.39	1.4
5. I can depend on the facts in the prescribed book for the rest of my life	1274	3.17	1.3
6. Successful students learn by heart notes given to them by their teachers	1279	3.05	1.2
7. The best way to learn science is to memorise facts and principles of science	1286	2.15	1.5

The significance of the results in the table above is that they indicate adherence to dysfunctional beliefs on the part of the students. The second and the 4th item for example are about the speed of learning. The belief here is that learning is fast or not at all. Students holding this belief cannot work persistently over a problem for a long time. The mean score of 3.90 and standard deviation 2.0 in the second item suggests that although many students agreed with the item some students strongly disagreed with it. Similarly the third, fifth and eighth items are about memorizing as a way of learning science. Although a large proportion of the students rejected the eighth item, their scores in the other items were higher than 3 suggesting that the students did not see these other items as similar to the eighth item. The rest of the items are about simplicity of knowledge and the scores indicate that the students consider knowledge to be simple. Students who believe that knowledge is simple may not appreciate the fact that knowledge depends on context. A resistor for example can be used to control current in a circuit in a series arrangement. In a parallel arrangement, however, the same resistor can be used to increase current in a circuit. Students who do not appreciate the contextual nature of scientific knowledge seek to memorise knowledge that may not apply in certain contexts. According to Schommer (2004) beliefs items about learning do not form one unified construct. Beliefs in Schommer's opinion are too complicated to be capture in one dimension. The table above indicates the kinds of beliefs about learning that students have and these do not form a unified construct.

7.4.2 Ability-related beliefs

A similar pattern dysfunctional beliefs, emerges in students' beliefs concerning ability. Descriptive statistics for ability-related beliefs are presented in Table 7.4 below. In keeping with Schommer's (2004) view on the nature of beliefs, the items in the table below do not form a single construct.

Table 7.3 Descriptive statistics of ability-related beliefs

Item	N	Mean score	Standard deviation
1. Only students who have ability to do well in physical science succeed in the subject.	1289	3.62	1.4
2. Even if one makes a great effort to do well in physical science, without ability to do well he or she	1278	3.15	1.5

cannot do well in science.			
3. Working hard on a difficult problem in physical science pays off only for good students. Scientists are born with ability to do science.	1288	2.79	1.4
4. Scientists are born with ability to do science.	1298	2.36	1.4
5. One's ability to learn physical science is fixed at birth.	1294	2.06	1.2

The scores in the items in the table above suggests that although many students reject the concept of natural or inborn ability they, nevertheless, consider ability to be something that is either present or absent in them and not something that develops out of their interaction with teachers and materials. Students who subscribe to the first and second beliefs in the table above may look at themselves as not having what it takes to succeed in learning physical science. This is indicated in the table by mean scores above 3. The reliability coefficient of these items was 0.38. This low reliability coefficient suggests, as Schommer (2004) maintains, that belief items are too complicated to be captured in one dimension.

7.4.3 Nature of science-related beliefs

Similar dysfunctional beliefs about science were found as indicated in Table 7.5.

Table 7.4 Descriptive statistics of nature of science-related items

Item	N	Mean score	Standard deviation
1. Facts of science do not change	1285	3.58	1.3
2. Scientific knowledge is an accurate and objective description of reality	1266	3.58	1.2
3. Knowledge of science is best characterized as isolated facts.	1281	3.39	1.2
4. Scientific knowledge changes with time.	1290	3.27	1.3

The scores in the first and fourth item suggest that the students perceived no contradiction in these items. Except for the fourth item the rest of the items are dysfunctional beliefs about the nature of science. The students have strongly held positivistic beliefs about science and science learning.

The selection of items included in the tables above was guided by published studies in the literature. Beliefs about learning have been studied extensively in many countries. What was done in this study was to find out the extent to which students in Malawi subscribed to some of the beliefs that have been presented in the literature.

7.5 Research question 4: What learning skills do students use when learning science after class hours?

The students were very limited in their knowledge and use of learning skills. The most commonly mentioned learning skill were reading and listening to others. Some skills such as visualization, problem solving and even memorising were rarely mentioned.

In view of the strong desirability bias among the students, I decided to ask the students to tell me what they do when they study on their own and to derive students' conceptions of learning from what they do when they study on their own. Six categories of things that students do to learn science were identified. These categories are: reading; consulting others; discussing with other students in small groups; re-doing what was done in class; problem solving and other categories. Typical examples of each category are presented below.

7.5.1 Reading

Reading was the most commonly cited activity that students performed in order to learn what was presented to them in class. Chrisy explains the role of books as follows:

> We have received books which are used by the students to read. The students are given books so that they should on their own time read the books.

Ellen concurs with Chrisy but adds another activity when she says “I consult certain students who do well in physical science apart from that I go to the library and read the books. John is more explicit about how he uses books:

> When I want to learn physical science on my own, I take a book from the library and read it. If I feel that I am not understanding what is being said in the book I take another book for reference that is a bit of another type not the same kind of book, then if also I am not comfortable, I now consult the teacher.

Some students indicated that reading was the only activity that they indulged in to learn science after classes. The following conversation Tape 2 no. 1 is a typical example of use of reading books as the sole learning activity after classes.

> I How do you learn science after classes?
> R By reading
> I By reading? Is there anything else you do apart from reading?
> R Nothing
> I Reading only?
> R Yes after classes yes.
> I You don't do anything else?
> R No nothing

Other students, however, combined reading with small group discussions and consulting teachers or other students. The category of consulting others is discussed next.

7.5.2 Consulting other students or teachers

Paul presented a typical example of learning through consulting other students in the following quotation.

> In physical science I actually learn through my friends. When it is time for class when the teacher is teaching I do not get what he is trying to say but actually it is through my friends so that they tell me what the teacher was saying.

Unlike Paul who depends solely on his colleagues in learning physical science, Talumba considers the role of teacher to be of paramount importance. She consults colleagues only to learn more information. Talumba maintains:

> First I get the information from the teacher, thereafter I do visit my friends so that I can learn more information then I do read my books, the physical science books which we were given.

Blessings, learns through asking and answering questions posed by his friends and himself. According to Blessings:

> Most of the times I and my friends during our free time we just ask each other questions about a topic which we are learning in class and in doing that we remind each other.

Sometimes the students consult other students in a small group discussion arrangement. Patricia for instance relates how the students consult other students to learn what was covered in class:

> We are in groups there in the hostels, may be five or three girls to be teaching one another. Those who understood a lesson when the teacher taught it teach those who did not understand.

Sometimes the other person consulted was the students' teacher. Miliasi relates:

> I listen very attentively to the teacher so that I should at least understand what he/she is saying. So afterwards I go to the hostels and go through that work. If I do not understand I go to the teacher and ask for assistance. If he/she assists me I feel better then it continues.

The category of consulting others as a form of learning included all those circumstances in which a student depended on other students or teachers to learn physical science after classes.

7.5.3 Discussing in small groups

Typical examples of this category are presented below. Some schools have established learning cycles as Macmillan indicates in the following interview extract:

> I How do you learn physical science after classes?
> R After classes we do take some physical science note books and study them and the teachers assist me in achieving more in physical science.
> I What do you mean when you say you "study them"?
> R Okay, after classes the topics e.g. on organic chemistry after learning in my class I do take my text on my free time and read what the teacher was saying and if I get something which the teacher did not explain well I do consult him or her and like that
> I What is it that you do to learn?
> R We have got study cycles where we meet and discuss some of the problems concerning a particular subject mainly in science such as physical science.

Contrary to the practice in Macmillan's school, in Mphatso's school there is only one study group organised and directed by the students themselves. Mphatso relates:

> R Here I just study and may be find out information may be discussing in groups and one discusses what one knows might teach the other you contribute so many views in that point then one day we might see ourselves that we are succeeding that our friends others are not aware of that academic work.
> I Do you have study groups here?
> R As of my side we had only one group which has got 15 members.
> I In the study group?
> R That I think is the only study group in this school.

Other students who referred to study groups were Kawonga, Shadreck and Aaron. I present below extracts from interview with them.

> We have discussion groups where we learn ourselves we discuss the things after the teacher has taught us (Kawonga)
>
> We practice in groups we give each other questions and afterwards we discuss the questions we have given each other (Shadreck)

> First of all I use some practices especially physical science because it is like mathematics we discuss in groups. (Aaron)

The category of discussing in small groups embraced all those circumstances in which students resorted to work in groups to facilitate learning.

7.5.4 Repeating the work or practising

In repeating class work the students sought to redo what they had done in class. Chancy explains how students study in this mode:

> As I have already said, the students are categorized into two groups. There are others who know what they are here for and those students who know their role do the work again and see where they had made mistakes.

In the following extract, Kondwani indicates that the practising method of learning is sometimes combined with other methods.

> I No let me say that you have learnt about friction in class and you want to learn more about friction on your own. What do you do?
> R I read in the library.
> I What do you read?
> R Things concerning that topic.
> I When you read do you just read or what do you do?
> R I read and practise.
> I What do you practise?
> R I practise how the things occur or the way things are being done.

Similarly Wanangwa said "We practice what we have learnt". In this same vein Kerfan said:

> After studying in classes we borrow some books in the library and practise more especially physical science because it has a lot of mathematics in it so we practice the mathematics after learning.

The category of practising what was learned in class implies doing again what the textbook does or what teacher did in class.

7.5.5 Problem solving

Selline provides a typical example of learning through problem solving when she says:

> When I am studying on my own for example when I am studying the topic on vibrations I use a book of model answers for physical science. I do try to answer those questions and to know that if I have this and if I see that there are some problems I go back to the teacher's notes and see where I have gone wrong.

Sometimes past examination papers provide the problems that students solve to learn physical science as Henery reports:

I give physical science a day on my timetable. On that day I either get a past paper or a book and I read the book and after that I find a past paper to answer from the past paper.

Charles actually searches for a problem to solve:

> First I find a problem, after I have found a problem then I go and look for information that I want to look for or after reading my notes if I find something that I do not understand well in my notes, I go and refer to the books for that topic.

Similarly Mateyu says he learns physical science by doing the "mathematics problems" in physical science. This category included all those instances where students referred to solving textbook or examinations questions as a means of learning physical science.

7.5.6 Other learning methods

These ranged from doing nothing after classes to elaboration and visualisation. Jane, for instance says she does not do anything after classes as indicated in the extract below.

> I When you learn science after classes what do you do?
> R After classes actually we do not do anything after classes because even if we want to practise something you are not able because the teacher may be not around so we do not do anything after classes after learning physical science.

The argument in the excerpt above seems to be that physical science is learned in laboratories. After classes students have no access to the laboratory especially when the teacher is not available. Students hence cannot learn physical science. This argument springs from the concept of science that the students have. Other students such as Charles use a different method of learning.

> To say for example when I learn the things I take them in my mind. I sit down on my own and think about them reasoning about them. I ask myself what will happen if such and such happen.

The excerpt above is the only example of use of elaboration learning skill that I came across throughout the study. The students seem to be very limited in their knowledge of what they could do to learn physical science.

Students' descriptions of what they do to learn physical science were extracted from the interview transcripts and classified into the six categories. There were a total of 56 such statements. Some students used more than one learning skill. Table 7.6 shows the number of times a particular skill was mentioned.

Table 7.5 Learning skills used by to learn physical science after classes

Learning skill	Number of times the skill

	was mentioned
Reading	27 (48.2)
Consulting other students or teachers	11 (19.6)
Discussing in small group	6 (10.7)
Doing what was done in class	5 (8.9)
Solving problems	5 (8.9)
Other	2 (3.5)

Percentages in parethesis

The learning skills in the "other" category, were elaboration and responding to the objectives of the topic. The predominance of reading as a learning skill is obvious in the table. All the students who mentioned problem solving except one failed to produce evidence of the problems they had solved previously. The shortage of textbooks in the schools implied that little student-initiated problem solving could take place in them. The students had limited knowledge of learning skills and sometimes used the skills superficially. Group discussion for instance was in one school used as a means of listening to good students about a topic after classes. Students' management of their learning was further explored through questions in the interview protocol to which I turn in the following paragraphs.

7.6 Research question 5: What self-regulatory skills, if any, do the students use when learning physical science?

The students showed minimal self-regulatory activity in their learning as indicated below.

Metacognitive awareness and self-regulatory skills were assessed through students' answers to three questions in the interview protocol. The questions were:

- What helped you in learning the kinetic theory of matter?
- What hindered your learning of kinetic theory of matter?
- How do you know that you learned the kinetic theory of matter?

Students' responses to these questions are presented in the following paragraphs.

7.6.1 What helped you in learning the kinetic theory of matter?

Four categories emerged from students responses to the first question. The categories were nothing, application of ideas learned in class to life outside, experiments done in class and demonstrations done by the teacher. Examples of the categories that emerged are presented next.

Nothing

The following extract is typical of the nothing category.

> I Were there things that helped you in your learning of the kinetic theory/
> R No sir,
> I No, nothing?
> R Yes (Mphatso)

Similarly Shadreck stated that nothing assisted him in his learning of the kinetic theory as indicated in the extract below.

> I Are there things that helped you in your learning of the kinetic theory of matter?
> R No

Responses in this category included all those situations in which the students felt there was nothing that assisted him or her in learning of the kinetic theory of matter or in learning any alternative theory that the student learned in the past.

Application of ideas to real life situation

The following extracts are typical of the application to real life category.

> I what helped you in learning the kinetic theory of matter? Was there anything that you think helped you to understand better?
> R Yes there was something because previously we did not know how water changed into gases form but when I study that kinetic theory of matter I know how things change from one state to another.

Tape four student no. 2 was assisted in learning about the kinetic theory by applying the ideas of the theory to physical situations as indicated in the following extract.

> I What helped or assisted you in your learning of kinetic theory of matter?
> R May be there is a big wall you are trying to break the movement of the Particles.

The student in the extract above considers the analogy of a brick wall where the bricks keep their fixed positions as in the arrangement of atoms in solid state as something that assisted her in learning the kinetic theory of matter. Other students, however, felt that it was the experiments they did that helped them in their learning of the kinetic theory of matter as indicated in the extacts that follow.

> I What helped you in your learning of the kinetic theory?
> R Yes concerning the experiments we did.
> I What helped you?
> R They helped me to remember just because the time when we were carrying out the experiments our teacher gave us the part that we did ourselves so that time time I do remember that when we were learning the kinetic theory we were doing this and that. (Selline)

> I Was there anything that helped you in your learning of the kinetic theory?
> R Yes.
> I What helped you?
> R We did an experiment.
> I An experiment?
> R Yes.
> I What experiment?
> R We took a candle which is in solid in form and we heated it and it produced the flame and that flame produces heat which melts the candle wax, it tells us that as the temperature increases the candle wax melts. (Tape 4, No. 1)

A fourth group of students felt that it was the teachers' demonstrations that helped them in their learning of the kinetic theory of matter. Mackmilan who claimed to have done static electricity and not kinetic theory presents a typical example in this category.

I What helped you in your learning of static electricity?
R Oh yes our learning was made easier by some form of demonstration.
I Who did the demonstration?
R The teacher.
I What were the procedures of the demonstration?
R For example on static element the teacher told us about charging a plastic pen by rubbing it against our hair so that at its end, the pen was able to pick up some pieces of paper showing that it has been charged.

The category of teacher demonstration represented all the situations where students referred to a demonstration done in class as something that assisted them in their learning of some theory. Students' statements were grouped into the categories and Table 7.7 portrays a summary of students' categories and their frequencies.

Table 7.6 Things that helped students' learning of kinetic theory of matter, N=22

Things that helped students in learning	**Numbers of times students mentioned the category**
Nothing	10 (45.5)
Application of ideas to life	5 (22.7)
Experiments done	4 (18.2)
Teacher demonstrations	3 (13.60

Percentages in parethenthesis

The majority of the students were unable to name things that helped them in their learning of the kinetic theory of matter. Many students, however, were able to name thing that hindered their learning of the kinetic theories as indicated in the next section.

7.6.2 What hindered your learning of the kinetic theory of matter?

Three categories emerged from students' answers to this question namely: lack of teaching and learning materials; nothing hindered the students in their learning and absence of teachers. Illustrative examples of these categories are presented below.

Lack of learning materials

I Are there things that hindered your learning of the kinetic theory?
R Yes.
I What are these?
R Lack of facilities in the laboratory.
I What is lacking in the laboratory? What equipment was required that was not there?
R The burners. We have got inadequate burners.
I What were the burners for?
R Burners are needed may be when we are doing a certain topic then you need burners.
I In the kinetic theory you say learning was hindered by lack of burners. What were the burners for? What use did you want to put the burners to?
R These burners are equipment like the relations between pressure and volume as well as temperature. (Chitha)

Nothing hindered learning

This category was sometimes motivated by a high sense of self-efficacy as illustrated in the following extract.

I Is there anything that hindered your learning of the kinetic theory?
R What do you mean?
I Is there anything that made it impossible or difficult to learn the kinetic theory?
R I think to my side it is not difficult for me to learn.
I So there were no hindrances.
R Ya no hindrances. (Tape 4 no. 2)

Absence of teachers

According to the students, teachers in certain schools abscond from classes frequently and some of the students consider teachers' absences from class a hindrance to their success in learning physical science. Selline for instances states "the teacher may be sometimes they have just they do miss their periods". Similarly Charles considers his teacher to be a hindrance to his learning because "teachers do absent themselves". It is their absence from class that makes teachers a hindrance to students' learning.

Students' responses were group into the three categories and Table 7.8 portrays my findings.

Table 7.7 Things that hindered students' learning of kinetic theory of matter, N=21

Hindrance	Numbers of times students mentioned the hindrance
Lack of learning materials	9 (42.9)
Nothing	8 (38.1)
Absence of teachers	4 (19.0)

Percentages in parenthesis

It is noteworthy that all the hindrances are outside the students themselves. The students in general seem reluctant to consider themselves to be significant contributers to their success. Students' responses to the item concerning self-assessment, is presented next.

7.6.3 How do you know that you learned the kinetic theory of matter?

The last question was about self-assessment. It showed that the students have not learned to assess their own work. Most students interviewed did not know what the question was about. Four categories emerged from analysis of students responses to this item. The categories were: no way of knowing; teacher assessments; ability to apply ideas to life and going over the lesson. Students' resposes that illustrate these categories are present below.

No way of knowing

Many students did not understand this item. It did not appear to have occurred to them before as the following extract illustrates.

I How do you know that you learnt the kinetic theory?
R (silence)
I May be you did not lern the theory because you cannot remember it?
R No I learned. (Wanangwa)

Similarly Ndaona in the quotation below appears to have no means of assessing his learning.

I How do you know that you have learnt the kinetic theory
R (long science)
I Are you able to monitor your learning?
I (after a long pause) Ok, it seems to me you do not do this.

Some of the students interviewed could not even understand the question suggesting their previous experiences excluded self evaluation.

Teacher assessment.

The following quotations from interview scripts suggest dependence on teachers for much of the students' work.

> Ok, in order for me to know that I have covered, there are some books at the library on which they have just asked question on a certain topic for example they just ask question on how to calculate moles. So when I study and after I know that, I have now finished I go to those books and try to answer some of the questions then I will expose them to the teacher to mark if I have got them right. (Steve)

Ability to apply or explain ideas

Some students claimed they use their ability to explain ideas to other or to apply ideas to a practical situation to assess their understanding. Mphatso for instance claimed to look for instances of application of theory in the following extract.

I Do you know that you have learned the theory?

R Yes I know.
I How do you know?
R He he he I think I can that how do I know that I leared the theory?
I Yes how do you know that you have learnt the theory?
R I can just say tha I know because I get to interpret some other things that I see outside, may be in our own stores or elsewhere so this is the kinetic theory which our teacher was telling us

Similarly student Tape 4, No. 2 claims in the extract below that he uses his ability to explain a theory to his friends to assess his learning.

I How do you know that you learned the kinetic theory/
R At least I could explain it to my friends.

Another student offered a more informed response:

> In the chapter of moles and molarity there are eight questions at the end of the chapter. I have answered all the eight questions. I have also checked the answers with those given in the textbook. I know that I have learn the chapter satisfactorily. (Chikwawa)

Students' reponses were classified into the four categories and my findings are presented in Table 7.9.

Table 7.8 Students' ways of knowing that they had learned the kinetic theory of matter, N=18

Way of knowing	Frequency of occurrence of the way of knowing in the data
No way of knowing	10 (55.5)
Teacher assessment	4 (22.2)
Ability to apply or explain ideas	3 (16.7)
Going over lessons	1 (5.6)

Percentages in parenthesis

Self-regulated learning presupposes awareness of one's learning processes, ability to monitor one's learning and ability to match learning tasks to appropriate learning skills. Most students' lack of knowledge of learning skills and ignorance of the need to assess their own work suggest that they are far from attaining a self-regulated status in their learning.

7.7 Research question 6: To what do the students attribute their failure in physical science?

As indicated in chapter 6 I applied the inductive analysis technique to students' responses to the attributions item. Nine categories namely: teachers, absence of science equipment, unavailability of books, physical science as a subject is difficult, students' laziness, low quality of teaching, problem with mathematics that is in physical science, unqualified teachers, changes in policy and other reasons emerged from the students' reponses. In the following paragraphs I present examples of students' responses that are characteristic of each category.

7.7.1 Teachers

Students considered teachers to be the greatest hindrance to their success in national examinations because they were lazy, unqualified, absent in class when they are expected to be teaching or the general quality of their teaching was low. The category of teachers' laziness was scored only where the students used the words lazy or laziness in describing their teachers or where they indicated that teachers were not doing what they are legitimately expected to do as teachers, like sitting in the staffroom when they are supposed to be in class. The anonymous questionnaires were numbered from 1 to 1,486. In referring to students' responses below I have used these numbers.

Student no. 55 for example writes about teachers: "The teachers are very lazy some of them come to school not on time". In similar vein student no. 78 maintains: "The teachers are lazy eg they just spend time chatting in the administration office".

Student no. 278 explains the things that hinder students from doing well in detail: "teachers use to miss other periods and spend most of their time entertaining the class through jokes". Student no. 499 is even more explicit about laziness of teachers: "The greatest obstacle to my doing well in physical science is the laziness of the teacher. Our teacher is not serious in our lessons". Similarly student no. 1139 writes: "There are two problems that led me to fail physical science. The first one is laziness of teachers". In similar vein students no. 1213 holds: "The second reason is that the teaching, itself, is poor and most of the teachers are lazy". The category of teacher laziness signified unwillingness of teachers to do what is legitimately expected of them to do as employees of government.

7.7.2 Unavailability of science equipment

The category of lack of equipment included all statements that indicated that the school in which the students were learning had not enough science equipment to enable the students to succeed in their learning. Student no. 378 explains the role of the school laboratory in these words:

> Laboratory was built for experiments so it happens that we are not using it because we are just learning without experiments yet MSCE needs more information through experiment this problem is for our teacher and lack of apparatus in the school.

After stating that one of the hindrances to their doing well in physical science is "Shortage of materials used in physical science subject at the laboratory" student no. 652 adds:

> The other thing about learning physical science I would like you to know is that physical science needs equipment for practicals and in physical science we do not just agree about something in order to know the truth about something we need to do an experiment to know what is true.

Similarly, student no. 880 writes:

> Lack of learning materials to prove the facts of science most of the times contribute to our failure in physical science.

Many students referred to lack of experience in doing practical work in science that is caused by absence of appropriate science equipment in the school as an important variable in their performance in national examinations in science.

7.7.3 Unavailability of books

The category of unavailability of books included all those statements in which the students implied that absence or shortage of books was a hindrance to their success in learning. Student no. 943 writes: “the greatest obstacle to my doing very well in physical science is lack of books so that I can find some information on my own”. Student no. 804, however, states that at his or her school the problem is that the books are not sufficient and the library is not managed properly:

> This subject (physical science) needs more memory and understanding but here our library does not manage to meet our needs. It has not enough physical science books and there is a rule which hinders my education here we are not allowed to borrow books from the library.

Student no. 1159 and many other students stated that their school lacks books. The practice in many schools is that all books are deposited in the library and students borrow them from the library from time to time. Teachers, however, can borrow a large number of books from the library and issue them to students when need arises. This category points to books as a lacking medium of learning in the schools

7.7.4 Physical science itself is difficult

Another category of students’ attributions of failure had to do with subject difficulty. In this category physical science was perceived as a difficult subject not because of the mathematics in it but because it is intrinsically difficult. The problem here may be related to students' ability to understand what they read in physical science books and what they hear from their science teachers. Student no. 457 is a typical example of this category. The student writes: "When I am reading I fail to understand what I am reading". Similarly student no. 373 writes:

> In physical science I find problems concerning the way the books were written, because they were printed with difficult ways and what they say about the chemicals and I do not understand the books when reading.

Student no. 1074 makes the language nature of this category more explicit. The student writes:

> I am not given notes, the book is very difficult for me to understand and it is also difficult for me to make my own notes. I can do better if I am given notes to study.

Student no. 1146 refers to language related perceived difficulty of physical science in these words "I do not understand very well other topics in the textbook like chemical bonds and the pressure". This category points to inability of the students to understand science texts and communication from teachers in science classes.

7.7.5 Students' laziness

The category of students' laziness included all instances in which the students saw their own laziness to be an obstacle to their success. Student no. 672 is typical of this category: "My reason for not doing very well in physical science is that I was lazy and did not work hard". Student no. 899 tells a story about the source of her laziness:

> Some time ago people told me that I just waste my time for nothing in learning physical science. So that comment makes me to be lazy in the time of learning

> physical science. And they told me to stop learning physical science because in the laboratory there many chemicals that are going to kill me one day.

Similarly, student no. 1193 writes about "laziness of the students" as an obstacle to their success in learning. This category included all instances in which the student points to his or her or to students' failure to do what is legitimately expected of them as a factor in their performance in national examinations.

7.7.6 Low quality of teaching

The category of low quality of teaching included all those circumstances in which in students' thought that teachers were doing what they were expected to do but were not doing it well. Student no. 475 writes in this connection about "poor teaching skill of some teachers". Student no. 778 is a typical example of this category. The student writes:

> Yes I have got some obstacles in my physical science work. The problem is with our teacher, he does not teach us properly. He teaches as if we know already. If we ask a question he does not answer instead he insults us and usually he asks questions without teaching us. If the fast learners answer his question, he does not teach that topic. This is the problem I see.

It was necessary to separate the category of laziness on the part of the teacher from the category of poor teaching because in some scripts the students' criterion for thinking that the quality of teaching is poor was not stated. Student no. 1150 is a typical example:

> My greatest obstacle to my doing very well in physical science is that of bringing in teachers who are teaching subject in which they are not good at and lack understanding when learning.

The criterion used to judge the quality of teaching may not be professionally valid. Student no. 1205 for instance states complains about the quality in these words: "Sometimes the teacher does not explain very well what he or she is teaching and sometimes they just say 'do it yourself' which is very bad". Whether the students were right or wrong in their assessment, this category indicates what students feel about the quality of teaching in their schools.

7.7.7 Problem with the mathematics that is in physical science

The mathematical character of some topics in physical science constituted another category. This category included all instances in which the students stated that the mathematical concepts and exercises in physical science were a hindrance to their success in learning the subject. Student no. 921 is typical of this category. The student writes: "Some of the obstacles I have met in my physical science lessons are the solving of some mathematics found in physical science". Similarly student no. 913 writes: "I think it's the mathematics we learn in this subject, its too difficult that is why I failed it". In this same vein student no. 1040 writes:

> The greatest obstacles to my doing very well in physical science are the calculations which are there. I do not understand some of the formulars used.

Student no. 837 concurs with the except above when he writes that what hinders him from doing well in physical science is "the rumour that says physical science is a very difficult subject in the sense that it combines with very hard mathematics to solve".

7.7.8 Unqualified teachers

The category of unqualified teachers signified all instances in which the students considered the qualifications of their teachers to be a hindrance to their success in learning physical science. Students seem to consider teachers with diploma qualification as unqualified. In the schools in which the study was done there were no unqualified teachers teaching physical science. There were, however, in two schools teachers with degrees in science but who had not yet done their postgraduate certificate in teaching. The following quotations are typical of this category.

Student no. 694 writes: "the teachers are not professional in their job because most of them are not graduates". In this same vein, student no. 738 writes: "we need teachers who have gone to the university". Similarly, student no. 797 writes:

> Teachers of physical science should be well qualified so as to teach a topic with confidence and bring understanding to the students. They should be applicable and fair to students.

Student no. 1148 writes in this connection: "The teacher who teaches me is not well qualified". The category of unqualified teachers included all those incidences in which the students specifically stated that their teacher was not qualified.

7.7.9 Other categories

There were minor categories that were combined together into other attributions category. These categories included background, time allocation, peer pressure and no response. Students in the background category felt that changes in government policy concerning physical science have resulted in their being forced to start learning the subject in secondary class 3 when their colleagues started learning physical science in secondary class 1. Physical science in some schools was still allocated 2 periods per week and students in such schools complained that the time allocated to the subject was insufficient. Other students did not respond to this item and the constituted the no obstacle category. There were also students who mentioned sickness, poverty, living far from school and noise during evening study, peer pressure and negative attitudes to science as reasons for their failure to succeed in their studies. These categories were combined into the other reasons category.

Students' attributions of failure in physical science in national examinations were tallied across the nine categories. Table 7.10 summarizes students' weighting of these attributions.

Table 7.9 Students' attributions of failure in MSCE examinations

in physical science.

Attribution	**Frequency of occurrence in the data (**
Teachers	1093 (33.2)
Lack of science equipment	643 (19.5)
Lack of books	531 (16.1)
Physical science itself is difficult	334 (10.1)
Students' laziness	284 (8.6)
No attribution	114 (3.5)
Problem with the mathematics	107 (3.1)
Started learning late	70 (2.0)
Too little time is allocated to physical science	63 (1.9)

Percentages in parenthesis

The teachers' category was further tallied into four sub-categories: teachers are lazy; the quality of teaching is poor; teachers are not qualified and there is shortage of teachers. The category "teachers are lazy signified extreme dissatisfaction with teachers while the category "poor quality of teaching" stood for mild dissatisfaction with the teaching taking place in the students' respective schools. Some schools had fewer teachers than were needed in the school. This is denoted by quantity of teachers in the Table 7.11. Although most of the teachers were qualified to teach physical science, the students considered teachers with sub-degree qualifications as unqualified hence the category "teachers' qualifications". Students' weightings of these attributions are portrayed in Table 7.11

Table 7.10 Weightings of students' attribution of failure to teachers

Attribution	**Frequency of occurrence in the data**
Poor quality of teaching	651 (59.6)
Insufficient number of teachers	228 (20.8)
Teachers are lazy	107 (9.8)
Teachers are not qualified	107 (9.8)

Percentages in parenthesis

The above table indicates common dissatisfaction with the teaching that goes on in most secondary schools. The results presented in this section are discussed in the following section.

7.8 Discussion

The following discussion is organized according the research questions. A general discussion of the factors that have affected and continue to affect students' performance is presented last.

7.8.1 Research question 1: How have students performed in science subjects in national examinations in the past?

All records indicate that performance of Malawian students in mathematics and sciences has been very poor. The results presented above confirm poor performance in science and mathematics. The following discussion of performance of students supports the finding that performance of students in the sciences has remained poor.

When three secondary class 2 (Standard 8) attempted and failed the Makerere Entrance Examinations at Zomba Catholic Secondary School, it was confessed that Nyasaland pupils had not yet attained the Makerere standard (Dep. Ed. Rep., 1944). In 1948 two Standard X students attempted and failed the Makerere Entrance Examination. The excuse for their failure was that the students "were really not interested" in the Makerere Examinations (Dep. Ed. Rep., 1948, p. 11). The missionaries and colonial administrators were in the habit of presenting lame excuses to forestall the need for remedial action. In 1953 seventeen students sat for the Cambridge Overseas School Certificate Examination (COSCE) and the results were "not regarded as satisfactory, as not one candidate obtained a first-class pass and only one qualified for Matriculation exemption" (Dep. Ed. Rep., 1953, p. 16). In 1960 it was reported that the "unsatisfactory nature of much of the primary teaching shows in poor results achieved by the secondary schools" (Dep. Ed. Rep., 1960, p. 22). The scarcity of very good passes in national examination was noted by the Malawi

Government in its Education Service Review Report that was compiled for the Government by Price Waterhouse. The report reads:

> In 1985/86 no candidate achieved six passes at "1" grading. There are alternative possible reasons for this: either teaching in Malawi is seriously deficient at secondary level, or the examination is a poor selection instrument (Government of Malawi, 1988, para, 175)

Comparison of examination results of Malawi with those of other nations suggests that it may be the teaching in secondary schools that is deficient. In his study of the relationship between cognitive development and word difficulty to performance in science among Rhodesian African secondary school children, Manyuchi (1981) used data from the COSCE to compare performance of students from Malawi Zambia and Rhodesia and ended up with Table7.7 below. Manyuchi used 1968 data because after that year the three countries started taking different examinations.

Table 7.11 Performance of students in COSCE in Zambia Malawi and Rhodesia in 1968

Country	No. of candidates	Percentage passing (%)
Zambia	1991	47.8
Malawi	1070	58.7
Rhodesia	1686	93.4

Source: Manyuchi (1981, p. 21)

A comparison school certificate results, of Zimbabwe and Malawi from 1971 to 1974 confirms the superior performance of Zimbabwean students portrayed in Table. 7.7. This comparison is presented in Table 7.8.

Table 7.12 Performance of students in Malawi and Zimbabwe at school certificate level

	Malawi		Zimbabwe	
Year	**No. candidates**	**Percentage pass (%)**	**No. of candidates**	**Percentage pass (%)**

1971	1956	54.9	2477	96
1972	2012	63.4	3032	94
1973	2440	55.5	3906	95
1974	2491	54.6	3981	92

Source: Manyuchi (1981, p. 21) and Ministry of Education, Malawi, (1979 p. 5.43).

The variations in the percentages of students passing the examinations in the Malawi sample suggest variations in the quality of teaching and learning from year to year in Malawian schools. In spite of their superior performance, Zimbabwe students, nevertheless, performed poorly in physical science as Manyuchi (1981, p. 22) reports.

> But though pupils from Rhodesia do register such high successes, the same pupils experience problems in studying science particularly physical science. Physical science teachers in Rhodesia often complain that despite well planned and seemingly well taught lessons a large section of the pupils at 'O' level find it difficult to grasp some science concepts involved in physical science and that much time need to be spent in consolidation and revision (

To substantiate his position Manyuchi states that in 1978 ninety-five percent of Zimbabwean 'O' level candidates passed English with grades 1 to 6 but only 48 % of the same sample of students passes physical science with the same grades. The problem being investigated in this study is consequently a problem within a problem. It is the problem of poor performance among students whose general performance in other subjects is poor.

Further evidence of poor performance in science subjects in Malawi has been provided by Higher School Certificate results in Malawi. Sixth Form classes in Malawi were meant to prepare students for admission into science oriented courses in British Universities. Table 7.14 shows Higher School Certificate results from 1970 to 1978.

Table 7.13 Higher School Certificate Results 1970-1978

Year	Number	Number of passes	Percentage pass

	Presented		
1970	29	12	41.4
1971	28	11	39.3
1972	28	17	60.7
1973	-	-	-
1974	26	17	65.4
1975	15	5	33.3
1976	26	13	50.0
1977	32	8	25
1978	27	3	11.1

Source Education statistics 1972/1973-1978/1979, Ministry of Education, Planning Unit

The Higher School Certificate classes were discontinued because they were not serving their function of producing science orientated students who would manage to gain places in Universities in Britain. The variation in the performance of the students suggests variations either in the quality of students or instruction.

The foregoing discussion indicates that the performance of students in Malawi has been poor. In the next section I turn to the students' beliefs of themselves as learners of physical science.

7.8.2 Research question 2: What perceptions of themselves, as learners of science, do the students have?

All measures of self-efficacy used in this study indicate that the students in general have a high positive academic self-efficacy. They think they have what it takes to succeed in learning science. This finding is in agreement with that of Cokley (2003) who found that African Americans maintain high academic self-efficacy in spite of their lower academic achievements. Against the background of perennial mass failure in science examinations, the students in Malawi consider themselves capable of doing very well in science.

In view of the strong desirability bias that I have already referred to, these results should be taken with caution. The students may have responded to the questionnaires on the basis of providing the "right" answer rather than on the basis of what is true for them. These results, nevertheless, make sense when considered together with findings of the last research question as indicated in section 7.8.6.

7.8.3 Research question 3: What epistemological beliefs about science and science learning do the students have?

The students hold positivistic beliefs about science and science learning. This finding is in accord with those of Edmonson and Novak (1993) and Chin (2003). Schommer (1990) refers to these positivistic beliefs as dysfunctional beliefs because they impede learning. As Edmoson and Novak (1993, p. 550) assert "science courses tend to be presented with a strong positivistic orientation and course evaluation frequently requires extensive verbatim recall of information".

The significance of these beliefs is that they affect students approach to learning. Students who have positivistic epistemological beliefs tend to be rote learners who aim at achieving high grades. Such students frequently resort to rote learning strategies. Insistance of the students in Malawi for teachers' notes supports the finding that the students have positivistic beliefs about science and science learning.

7.8.4 Research question 4: What learning skills do students use when learning science after class hours?

The main learning skills used by the students are reading and listening. Group discussion among most of the students is not the time when they think seriously about a topic but the time when they listen to a student who understood a lesson when it was presented by their teacher.

The most serious deficiency in the students studied is their lack of knowledge of learning skills that they can use in learning physical science. Letteri (1992, p. 59) asserts that one of the most important factors that contribute to differences in achievement among students is "the profile of cognitive skills that a student brings to academic tasks". In Letteri's opinion, without the cognitive skills students can never be self-directed in their studies. In similar vein Cotton (1995, p. 69) states that young students "need to learn the art of learning". The students who participated in the study learn mainly through reading teachers' notes and listening to other students. Use of learning tactics such as problem solving, summarizing, and drawing diagrams is hampered by the non-availability of resources, manner in which the schools are managed and attitudes of the students to each other as summarized in the following paragraphs.

Most students in the schools had no textbooks issued to them. Many students do not even know the two textbooks that are prescribed for physical science. The following quotations demonstrate that some of the students did not even know the books they were supposed to use in preparing for their examinations.

I Do you know the prescribed books for physical science?
R What?
I The books that MANEB has said you should read.
R No.
I You do not know/
R No.
I do you think it is right for you not to know the books that the examination body you are preparing for has set aside for candidates to use?
R No.
I Why is it that you do not know the books?
R The teacher didn't tell us that we should read these books. (Kerfan)

I Do you know the prescribed books for physical science?
R The what?
I The prescribed books. The books that MANEB has said you should read.
R No, I just know the syllabus I do not know any prescribed books. (Selline)

In some interviews the students claimed to know the prescribed books but showed through their responses to my probing questions that they did know the prescribed books. The following extract from interviews illustrates this point.

I Do you read the prescribed for physical science, the books that MANEB has said you should read?
R Yes
I Which are they?
R Organic physics.
I By who? Is there a book called organic physics?
R Chemistry. (Manfred)

Students' ignorance of the prescribed books suggests their low level of engagement with learning tasks. Comparison of findings of this study with similar studies done elsewhere (Little, 1985; McCallum, Hargreaves and Gipps, 2000; Tsai, 2004) indicates that it is in the area of learning skills that the students in Malawi are most disadvantaged. Although many young children are reported in the studies to match learning skill to appropriate learning task the students in Malawi appear to use reading and listening as universal learning strategies. To some students memorization has no role in learning science, as the following extract from the interviews shows.

I Is physical science easy or difficult to you?
R Physical science is not difficult.
I What makes it easy?
R Because physical science is the subject which does not allow somebody to memorize so if you can memorize you can't understand physical science, you have to understand everything in the textbook and everything given by the teacher.
I Is it not necessary to memorize things like the symbols of elements?
R It is .
I So why then are you saying it a subject that does not allow anybody to memorize?
R Because the examinations of physical science how they come if can memorize the formular may be they can ask you something to know your knowledge if you memorize you cannot be able to answer that question. (Tape 1, No. 1)

As is obvious in the quotations above the students' ability to express themselves in English is poor and their knowledge of learning skills and strategies is also poor.

7.8.5 Research question 5: What self-regulatory skills, if any, do the students use when learning physical science?

There was among the students little evidence of planning and monitoring their work. The item on predicting possible grades in national examinations in the following year was greeted with great surprise. I had to explain it to the students several times at each school. It seemed that the students never thought about possible grades before the administration of the questionnaire. The students do have some rudiments of self-regulation in their learning such asking themselves questions and some students solve problems placed at the end of each chapter in their books. Self-regulated learning, however, requires not only knowledge of learning skills but also ability to match learning tasks to learning skills that work for the individual student. The students have yet to become aware of their abilities and limitations in learning.

Self-regulation in learning requires self-assessment. Some of the students do not think it is possible for them to assess themselves. They consider it the role of their teacher to assess them and tell them how well they are performing.

7.8.6 Research question 6: To what do the students attribute their failure in physical science?

The students attribute their failure to their teachers. The following quotations from interview transcripts illustrate students' attribution of success or failure.

> I think the way some teachers teach us is the greatest obstacle to our success better performance because a student can be a lazy student but when a teacher is hard working that laziness ceases and the student becomes very active. (Richard)

> I think the performance in two schools can be different because teachers who teach in those schools are different in the sense that some are skilled and are trained in a special way. They know how to use the science materials and it won't happen in the other schools the teachers don't know how to use science equipments then those who do not know cannot teach the students to perform

> well. This that students which are at the school where is a skilled teachers, they are going to perform well. (Lufeyo)

> In a certain school where there are teachers that are encouraging the students not to feel that the subjects are difficult, the school can perform well but the teachers if they do not encourage the students to concentrate on those science subjects then the school cannot perform well. (Anderson)

> In this school we find that teachers, may be, do not come to class in time or sometimes there are many absents to them to attend the class of the teacher. We also find that many teachers actually are not well experienced or trained for that particular subject. They are just taken because there is lack of teachers. (Chancy)

Even when the students refer to student-related factors of underachievement, they end up pointing their finger at the teacher as illustrated by Mary in the following excerpt:

> I must mention that one reason can be the concentration of the students themselves and also the teachers may be at another school the regulations are followed which cause study and to concentrate much on educations while another school is loose on rules and regulations therefore leaving the students just roistering around in time of study and also learning, therefore in the school performance can be different because that one is causing students to study, they can have high concentration on education while another school is loose on regulation which would make students to concentrate much and perform higher in their education. (Mary)

The argument in the excerpt above is that teachers are responsible for enforcing the rules and regulations that cause students to concentrate on their learning. The students seem to take themselves to be passive responders to quality of teaching in the schools, where the quality of teaching is good, students respond by doing very well and vice versa. One of the students expressed their attitude to work in this connection succinctly: "we read and do what we have been told to do on that topic" (Chirwa).

It is important to note that although the students have high positive self-efficacy beliefs, the performance in national examinations in physical science has remained poor. Their high self-efficacy beliefs are in effect forms of self-deception. The students seem to continue living in the glories of their past achievements in national examinations without working hard for the next examination as suggested by missionaries at Nkhoma mission (Dep. Ed. Rep.,1953, p. 3).

7.8.7 Common factors affecting students' performance

Two factors, namely: fear of education for Africans and poverty streak through the colonial and post-colonial periods in the history of education in Malawi influencing educational policy. Sir Harry Johnston, the first Governor of Nyasaland explained the sources of the fear of education for Africans succinctly in 1916when he wrote:

> In short, all Governments, most Government officials and nearly all masters of Europe's trade and industry connected with Africa, would prefer if they spoke their utmost thoughts to re-establish slavery all over Africa…But the time for such a phase in African history has gone by. The missionaries have sown the dragon's teeth of education (Johnston, quoted in Shepperson and Price, 2000, p. 380).

Dragon's teeth referred to in the excerpt are obstacles that resemble teeth pointed upwards and are used against tanks in war. The implication here is that educated Africans were obstacles that prevented Europeans from exploiting Africa's cheap labour. In similar vein, Gaunt (1927) the first Director of Education in Nyasaland, following Lugard (1922) wrote of yet another dangerous aspect of education for Africans- the rebellious character of educated Africans. Gaunt maintained that learning of Africans can be a dangerous thing if it is not carefully controlled. The Chilembwe Rising of 1915 had demonstrated that discontented educated Africans can resort to the use of arms to achieve their objectives.

Acting Governor Hall was motivated by the fear of educated Africans when he said that people in Nyasaland should be thankful that the colonial government took a long time before it stated supporting education of Africans (Hall, 1932). Hall's thinking was that if the colonial government had started supporting education at its inception, the country would have then been full of rebellious Africans. In the post-independence period the reduction of number of periods per week for teaching science from 5 to 2 appears to have been motivated by the fear of the scientifically educated Africans. The post-independence rulers were interested in raising citizens who would obey without asking questions. Science, however, promotes universal skepticism. The science that is currently taught in primary schools in Malawi is confined to a study of living and non-living objects and would not promote universal skepticism among children. The fear of scientifically educated citizens may still be present in society in Malawi today in subtle forms.

In 1927 Governor Bowring introduced a bill aimed at empowering the Nyasaland Government to assume strict control of education but poverty of the country persuaded him not to do so. In his memorandum of native education of 23rd July 1928 addressed to the Colonial Office in London, Bowring wrote:

> Objects raised by missionary societies to strict control by government unaccompanied, by adequate grants in aid of missionary enterprise. I feel unable to refute this charge and have accordingly come to the conclusion that we must give way.
>
> The most important innovation is that under the new bill missionary societies will be allowed to establish and maintain any number of vernacular schools of any standard without restriction or regulation (Bowring, 1928, CO 525/124, Vol. 3)

It was in the view of missionaries better to have poorly administered bush schools than to have no school at all. In this incident poverty of the country determined educational policy to be pursued. There are many instances in the educational history of Malawi in which educational plans, recommendations of commissions of inquiry set to investigate specific issues in education, that were adopted by the government, were , nevertheless, not implemented because of lack of funds (Lamba, 1984). Phillips' Commission refers to poverty as "lack of money" (Phillips Commission, 1962, p. 12). The post-independence period has been characterized by expansion of the provision of education without taking into account availability of funds for sourcing school equipment, classrooms, and teachers because of poverty. The implementation of Free Primary Education (FPE) is a case in point. Financial implications of the FPE program were ignored and this resulted in reduction in the quality of outputs of the primary schools.

7.9 Conclusion

This chapter presents and discusses results of the study. It suggests that poverty and unwillingness to face challenges that characterized education in the colonial era have continued unchecked in the post independence period. It is possible that underachievement in science may have been consciously nurtured by some the post independence governments. The data suggests that students are not adequately prepared in earlier years to succeed in their learning of science subjects. In the next chapter I draw conclusions from the literature reviewed and the data collected and analysed.

Chapter Eight
Conclusions and Recommendations

8. Introduction

In this chapter I pull together threads of my argument and attempt to go beyond the analysis conducted in chapter seven in answering the central research question of the study namely: what keeps highly selected students in Malawi from performing at their expected levels in national examinations in physical science? The chapter is organized into six sections. In the first section I summarize findings from the literature review and from the analysis of the data collected during the study. Final conclusions about the research questions of the study are presented in the second section. In the third section, I discuss the implications of the study to the problem of poor performance in science among students in developing countries. The fourth section presents the recommendations for further research and for educational practice in Malawi. In the conclusions section I argue that focusing on historical background of students' learning and on what students actually do, after classes, to learn content and skills that are presented to them in the course lessons, open new possibilities for explaining poor performance of students in African countries. I urge scholars to replicate the study in other developing countries. In the last section I discuss the limitations of the study.

8.1 Findings from the literature review and analysis of data

This section begins with a summary of the aims of the study and research procedures used. Then follow summaries of findings from the literature review and analysis of the data.

8.1.1 Aim and methods of the study

The aim of the study, it may be recalled, was to explore the problem of poor performance in science in Malawi, a country that has experienced this problem since 1942. It was known at the inception of the study that students in other countries such as Tanzania and Zimbabwe did much better in national examinations in science subjects than Malawian students (Chipembere, 2001; Manyuchi, 1981). The overall theoretical framework of the study is constructivism and the findings are interpreted from that perspective. The mission of the study was to investigate selected dimensions of the problem so as to enable the researcher to suggest possible solutions to the problem as it is experienced in Malawi.

The mixed method design was used in the study. The study started with examination of archives that was followed by administration of questionnaires. Individual and group interviews concluded the data collection phase of the study. The interviews provided the researcher opportunities to investigate further issues arising from students' responses to the questionnaires. The interviews formed the main thrust of the study. Students' responses to questionnaires were analyzed using SPSS (Field, 2000; Pallant, 2001). Examination of archives involved following up issues in intended and unintended documents so as to determine the motives of key players at that time. Qualitative methods were used in analyzing interview data (Hatch, 2002; Schostak, 2002; Rudestam and Newton, 1992).

8.1.2 Findings from the literature reviewed

Within the realm of the findings of the study and the limitations of the literature reviewed, the following conclusions seem justified.

Research question 1: How have students performed in science subjects in national examinations in the past?

1. Performance of students in national examinations in science in the past has been poor.

2. No effort was made to improve performance of students in the Makerere Entrance Examinations in science and mathematics in the 1940s and 1950s.

Judging from official correspondence and minutes contained in files found at the National Archives, there was in Malawi in the early 1930s a pronounced opposition to the introduction of science subjects in schools among the colonial administrators and some missionaries. It seems that the colonial administrators in Malawi followed their own policies that sometimes contradicted policies of the Colonial Office in London. Although, for instance, Makerere College was established by the British Government (Proceedings of the Inter-territorial Conference, 1938; Onabamiro, 1964), the Director of Education in Nyasaland was, nevertheless, able to write to his superiors that "Makerere must not be allowed to deviate the secondary schools in Nyasaland from their purposes" (Lacey, 1937, p. 6). This suggests that the purposes of Makerere College were in the view of the Director of Education, different from those of secondary schools in Nyasaland. Makerere College emphasized the teaching of science subjects, some missionaries and colonial administrators, however, were opposed to teaching science to Africans.

Secondary schools in Nyasaland in the 1940s and early 1950s failed to raise the standard of performance of students to the level required for admission to Makerere College. Initially, failure of Nyasaland students in Makerere Entrance Examinations was explained away in terms of the fact that Nyasaland students were taking the examination after two years of secondary education. The Dep. Ed. Rep. (1944, p. 6), for example, reads "Although the Makerere Entrance Examination is about Standard X, three students attempted it and proved definitely that Nyasaland pupils have not yet attained that standard." According to letter Ref. No. M. C. 32/IX of 15th June 1938, the Cambridge University School Certificate Examination, the Makerere College Entrance Examination and some Junior Secondary Leaving Certificates such as the Kenya Junior Secondary Leaving Certificate were accepted as entry qualifications (Acting Principal, Makerere College, 1938). In 1948 two Standard X students sat for Makerere Entrance Examinations and failed (Dep. Ed. Rep., 1948). It seems that Nyasaland students settled for a standard lower than Makerere Entrance Examination and have yet to raise the quality of their work to the level required for admission to Makerere College.

Research question 2: What perceptions of themselves, as learners of science, do the students have?

1. Students with low self-efficacy in learning science are unlikely to succeed in their learning of science.

Students who have low self-efficacy perceptions of themselves as learners of any subject are more likely than those with high self-efficacy perceptions to give up learning when faced with difficult tasks, to show negligible commitment to the goals they choose to pursue and to attribute their lack of success to other factors other than themselves (Mayer, 2003; Bandura, 1997).

Research question 3: What epistemological beliefs about science and science learning do the students have?

1. Students' epistemological beliefs affect their approach to learning and subsequently their achievement in science learning.

Students who hold such beliefs as learning is increase in knowledge, learning is memorizing and, learning is acquisition of facts and procedures are unlikely to succeed in their learning of science (Kember and Gow, 1989; Schommer, 2004). Such students use rote-like learning strategies and are oriented to grades rather than to understanding ideas (Chin, 2003). As Shapiro (2004) notes, students' beliefs about learning are key to understanding the way they learn.

Research question 4: What learning skills do students use when learning science after class hours?

1. Knowledge and use of various learning skills, when need arises, facilitates learning in any subject.

Students' learning improves when the students spend some time in consciously choosing and using learning skills and strategies. According to Garner (1990, p. 518), "effective learners are strategic when they need to be." Bransford and Donovan (2005) add that gains in learning are particularly larger with lower-achieving students than with higher-achieving ones when both groups are taught to use metacognitive skills. Kozulin (1998) recommends, in this connection, that emphasis in education of disadvantaged or minority students should be on learning strategies, metacognitive functions, and conceptual literacy.

Research question 5: What self-regulatory skills, if any, do the students use when learning physical science?

1. Students who plan, monitor and manage their learning endeavours using knowledge that they have acquired of themselves as learners are likely to succeed in learning science.

Self-regulation of one's learning is the "the key to helping all pupils to become better learners thus empowering them" (Quicke and Winter, 1994, p. 430). The concept of self-regulation of learning emphasizes the importance of personal initiative and involvement in learning. Zimmerman and Martinez-Pons (1986) define self-regulation as the extent to which a learner is metacognitively, motivationally and behaviourally active in his or her learning.

Research question 6: To what do the students attribute their failure in physical science?

1. Students who attribute failure in learning to factors outside themselves are unlikely to improve their performance when they perform poorly.

On the basis of causal attributions of their achievements in academic tasks, students make judgements of responsibility. It is these judgements that influence affective experience and future reactions to success or failure in learning (Hogg and Vaughan, 2005). Attributions of success or failure point the extent to which a learner takes personal responsibility for his or her learning.

8.1.3 Findings from analysis of questionnaires and interview transcripts

Within the limitations of the methods used to collect and analyze data collected in the course of the study, the following conclusions appear justified.

Research question 1: How have students performed in science subjects in national examinations in the past?

1. Performance of students in science subjects has been poor and the trend is that unless some drastic action is taken, performance of students is likely to worsen with time.

Records indicate that performance of students in science and mathematics in the country has remained poor. Recent studies such as Malawi Government (1988) and Malunga Commission (2000) speak of poor performance in most subject incuding science and mathematics. This study has shown that the average failure rate in physical study increased from 31% between 1984 and 1993 to 41% between 1999 and 2003.

Research question 2: What perceptions of themselves, as learners of science, do the students have?

1. The students have high positive self-efficacy perceptions of themselves as learners of science.

To the majority of the students physical science is an easy subject to learn. The students predict for themselves higher scores than those that have been achieved in the country in recent years. This finding contrasts sharply with the performance of the students in national examinations.

Research question 3: What epistemological beliefs about science and science learning do the students have?

1. The students hold positivistic beliefs about science and science learning.

2. Science to most students is the study of living and non-living things.

The participating students hold many beliefs about science and learning that lead them to using ineffective styles of engagement in carrying out learn tasks. Although most of the students rejected memorization as a way of learning science, they, nevertheless, accepted looking for the facts given by the teacher and learning the facts and principles of science by heart, which are all forms of learning through memorizing content, as reliable means of learning science.

Research question 4: What learning skills do students use when learning science after class hours?

1. Reading and listening were the most commonly used learning skills among the students

The most frequently mentioned learning skill was reading. Many students seem ignorant of other learning skills other than reading and listening. Lunch-hour discussion groups are sporadically organized in some schools but the purpose of these is to provide students with opportunities to listen to students who happened to have understood a lesson when their teacher was presenting it. One school has a discussion group of 15 students who meet regularly to discuss mainly past examination questions. Most schools did not have students' initiated learning activities.

Research question 5: What self-regulatory skills, if any, do the students use when learning physical science?

1. Some elements of self-regulated learning such as asking oneself questions about the topic one is learning were detected among the students in the

course of the interviews, but control and management of one's studies was demonstrated by one student only.

Students' ignorance of learning strategies other than reading or listening to other students meant that they could not use metacognitive and self-regulatory learning skills for these skills presuppose ability to match learning task to appropriate learning skills. In all the schools students appeared surprised and puzzled when I asked them to predict the grades they are likely to achieve in the national examinations in the following year, suggesting that such a question never occurred to them before. Students' ignorance of the prescribed books for physical science meant that they are most probably only superficially involved in their studies.

Research question 6: To what do the students attribute their failure in physical science?

1. The students attribute their failure in physical science mainly to external factors.

Students attribute their failure to their teachers. Attribution of failure to teachers suggests that the students are not intrinsically motivated in their learning of physical science. According to Hogg and Vaughan (2005) students' attributions of task achievement are influenced by their perceptions of the locus, stability and controllability of their performance. The students in the study seem to indicate that they have little or no control over their performance.

The Malawian students depicted in the statements above presents a bit of a psychological puzzle. A high positive self-efficacy coupled with dysfunctional beliefs about science and learning, ignorance of learning skills and apparent lack of intrinsic motivation. It seems that the high positive self-efficacy is a result of the strong desirability bias and that it bears no relation to the students' performance in physical science. The students hence see themselves as very capable of learning physical science when they are in effect not so capable because of limitations in their previous experiences. This situation is akin to that of African Americans who detach their academic self-esteem from their academic performance to protect it (Cokley, 2003).

8.2 Final conclusions

The purpose of this study it may be recalled was to explore the problem of poor performance in science through inquiry into the history of the problem and the images of science and science learning that students in secondary schools in Malawi hold. In this section principle conclusions of the study are presented.

8.2.1 Principal conclusion of the study

Taking into account findings from the study of archives, the interview transcripts and analysis of the questionnaire on learning beliefs and practices, the following principal conclusions appear justified.

Research question 1: How have students performed in science subjects in national examinations in the past?

Students have performed poorly in the past because no effort has been made to raise the standards of performance to those attained by other East African Countries such as Tanzania and Ugandain the early 1940s and 1950s.

This finding confirms previous finding (Malunga Commission, 2000; Malawi Government, 1988). Things that happened in the history of Malawi such as rebellion of early successful students, perpetual shortages of teachers in secondary schools in the 1940s and 1950s, unwillingness of the colonial administrators and some missionaries to teach science to Africans resulted in the nation settling for a lower level of performance in its secondary schools than the level of the Makerere Entrance Examination. This settling for a lower level of students' performance is the "traditions established by the colonial regime" of which Chipembere says "persists for many years afterwards even after a change of rulers" (Chipembere, 2001, p. 73-74). Malawian students have performed poorly in examinations especially in science and mathematics since secondary education was established in the country in the 1940s and the secondary schools in the country have yet to improve their performance in science subjects to the Makerere standard.

Research question 2: What perceptions of themselves, as learners of science, do the students have?

The students think they can learn science successfully but what they do on their own initiative to learn science is not adequate for them to succeed in learning science subjects.

The students believe that they have what it takes to succeed in learning physical science. The majority predict for themselves higher grades than the grades that have been achieved in recent years. Most students find physical science an easy subject to learn. They perceive themselves as highly capable of learning physical science in spite of of the long history of poor performance in the sciences in national examinations. The absence of individual initiatives in learning among the students suggests that the high positive self-efficacy may be another form of the social desirability bias that I have referred to previously.

Research question 3: What epistemological beliefs about science and science learning do the students have?

Students' beliefs about science and science learning are some of the obstacles to their success in learning.

Most students have positivistic beliefs about science and science learning. These beliefs lead them to adopting memory based learning strategies. As Braten and Stromso (2005) maintain, beliefs about knowledge and learning constrain one's understanding of what knowledge is and how it can be acquired, at a critical level.

Research question 4: What learning skills do students use when learning science after class hours?

Students' limited knowledge of learning skills is one of the factors that have to be addressed to improve learning science in secondary schools in the country.

For learners to become strategic in their studies, they need to have a repertoire of learning skills. Absence of knowledge of learning skills or strategies in the learner, forces him or her to use one learning skill as a skill for all occasions. The multi-dimensional concept of learning, however, emphasizes the need to match learning task to appropriate learning skill.

Research question 5: What self-regulatory skills, if any, do the students use when learning physical science?

Self-regulatory skills are not common among the students. Prerequisite skills for self-regulated learning are lacking in most students.

Planning, monitoring and controlling their learning were seldomly reported by the students interviewed. Most students get their feedback from their teacher and are not able to assess their own work. The absence of textbooks and, lack personal involvement and initiative in learning, on the part of the students, means that self-regulatory skills can hardly develop among them.

Research question 6: To what do the students attribute their failure in physical science?

Students' attribution of failure may be a defense mechanism that allows them to do negligible work but maintain high positive self-efficacy beliefs in learning science.

If one's causal attribution of success or failure in an academic task denotes one's acceptance or denial of responsibility for one's performance in academic tasks (Hogg and Vaughan (2005), then the participating students have not yet accepted responsibility for their performance. Their style of attribution allows them to cling on to high positive self-efficacy perceptions of themselves in an atmosphere of perennial poor performance in science.

8.3 Implications of the study for science education in developing countries

The implications of the study for science education in developing countries are twofold: agency is as important as system or structure in the performance of students and students' previous experiences in learning have a bearing on their future performance.

8.3.1 Agency versus system of structure

In many approaches to the problem of poor performance in science among minority students and students in developing countries, more emphasis has been placed on changing the system to suit the student. The student has been assumed blameless.

The general trend in practices has been to blaim the structure or system rather than the "victim" (Carbonaro, 2005, p. 44). The data presented in this study suggests the importance of personal involvement and initiative in learning. Ogbu (1992) points out, in this connection, the need for minority students to take responsibility for their own academic performance. Most students interviewed said they "do what the teacher tells them to do". As previously indicated, most of the students did not know even the prescribed books that they were expected to study in preparation for their examination in physical science. Personal involvement and commitment to learning are indispensable if learners are to succeed in their learning. The science curriculum has been modified a number of times in the post-independence period in Malawi but no study has been done on students' involvement and commitment to their studies. This study suggests that both agency and structure or system, are important in students' performance in the sciences.

8.3.2 Role of previous experiences

This study has shown that previous individual and national experiences matter in determining level of students' performance. Educational traditions establish long ago continue to affect students' learning many years afterwards (Chipembere, 2001). In the absence of common international tests, these traditions are hard to detect. In the case of the students who were interviewed some of them felt surprised when they realized that they could do more to learn physical science than what they had been doing. When the need for the students to take responsibility for their studies and demonstrate personal involvement and initiative was explained to the students, they wondered why these things had not been mentioned to them in the course of their schooling. It seems that the traditions once establish become invisible to students and teachers.

Learning experiences acquired in the course of schooling may be deficient to facilitate successful learning in secondary. This is the problem that Phillips Commission (1962) noted in Malawi when they recommended raising the quality of primary school graduates. It seems that schools that are situated in the historical and financial context of the country promote among students concepts of learning that would not support successful science learning. The implication here is that past experiences of a nation may be at the root of the problem of poor performance in science as is the case in Malawi. The past experiences, however, are but one of the factors influenceing students' learning.

8.4 Recommendations for further research and for educational practice

In making the recommendations that follow I have focused on science teaching and learning in Malawi and have ignored the broader nature of the problem under investigation. Recommendations for further research are presented first and are followed by recommendations for educational practice.

8.4.1 Recommendations for further research

1. In its early phases this study had one objective that involved finding out what students do in their exercise books. The idea was to find out how much the students do in terms of homework and in terms of their other learning endeavours. This objective has had to be dropped because the reversal of the policy concerning physical science meant that a fair assessment of students' work would not be possible. The period allocation of physical science was reduced from 5 to 2 periods per week. Some schools started learning physical science in the week I visited the school. In those schools where I had chance to see exercise books of students who had learned physical science for one year, there was very little homework. In one school students had homework once in a year. In two schools the only tests that the students took were the terminal tests. I recommend that a thorough study of what students do in terms of home, class work and tests be carried out.

2. The teaching of learning skills has been shown in the literature to improve students' learning (Dart *et. al.*, 2000). The emphasis in teacher training college and faculties of education in Malawi has been on teaching rather than learning skills. I recommend

that an intervention study be carried out to determine the effect of teaching students learning skills on their performance in science. Such a study should control other variables that are likely to affect its results.

3. Teachers were not the focus of this study. Students' statements in the questionnaire and during interview suggest that all is not well with teaching. According to the students, teachers absent themselves from class and do not test the students frequently. In two schools I saw teachers sitting in the staffroom when they were supposed to be teaching. In some schools the only test that students take is the terminal test. Some educationists have suggested that students are paid in marks for their work. It seems that many teachers deprive their students the opportunity to work through giving little or no work to do. I recommend that a study of the way teachers in the country teach their students be done to determine what is happening in the schools with regard to teachers. .

8.4.2 Recommendations for educational practice

1. Independence in Malawi was not followed by re-conceptualization of the history of science learning. Many students continue to see themselves in the images of some missionaries and colonial administrators as people who cannot succeed in learning science and mathematics. The conflicts that characterized the relationships between teachers and students during the colonial period, continue to retard teaching and learning in the post-independence period. Some teachers today, like teachers during the colonial period, think that their students cannot do physical science. This is borne by the fact that many schools stopped offering physical science arguing that the subject was too difficult for the students to understand. The constructivist perspective on learning holds, nevertheless, that students' failure in school reflects the manner in which the students were taught. I recommend that a re-conceptualization of schooling, failure of students, students themselves and of science and mathematics education be carried out and be communicated to students and teachers.

2. It seems that children in Malawi have had no fair opportunities to demonstrate their ability in learning science and mathematics. Poverty or fear of the scientifically educated person interfered with science education from time to time. I recommend that three schools be chosen, one in each administrative region to serve as models for teaching and learning science. The chosen schools should be serviced by the best of our teachers and educational administrators and, books and other school equipment should be made available to these schools. The purpose of the chosen schools will be to show that students in the country can work hard in science and mathematics and succeed like students from any other nation. The teachers and students in these schools should be informed about the purpose of the schools. The Faculty of Education in the University of Malawi and the Advisory Service in the Ministry of Education should work together in setting up, in the selected schools, environments in which focus of activities will be on students' learning.

3. Learning science in Malawi is learning content of science. Syllabuses are merely lists of topics to be covered in the course of schooling. Education, however, "is much more accurately described as learning to learn" (Centre for Innovations in Education, 2000). I recommend that learning skills and strategies be embedded in the science content and that, teachers be trained in promoting students' learning through students' awareness and use of learning strategies.

4. Training of teachers in teacher training colleges and in the faculties of education in universities in the country focuses on communicating to teachers teaching skills rather than learning skills. I recommend that at secondary levels the training of teachers should be based on the assumption that most of the students in secondary schools are disadvantaged students in that they have not yet developed learning skills. Figure 8.1 summarizes my recommendation about the topics that must be included in a teacher training course for secondary school teachers.

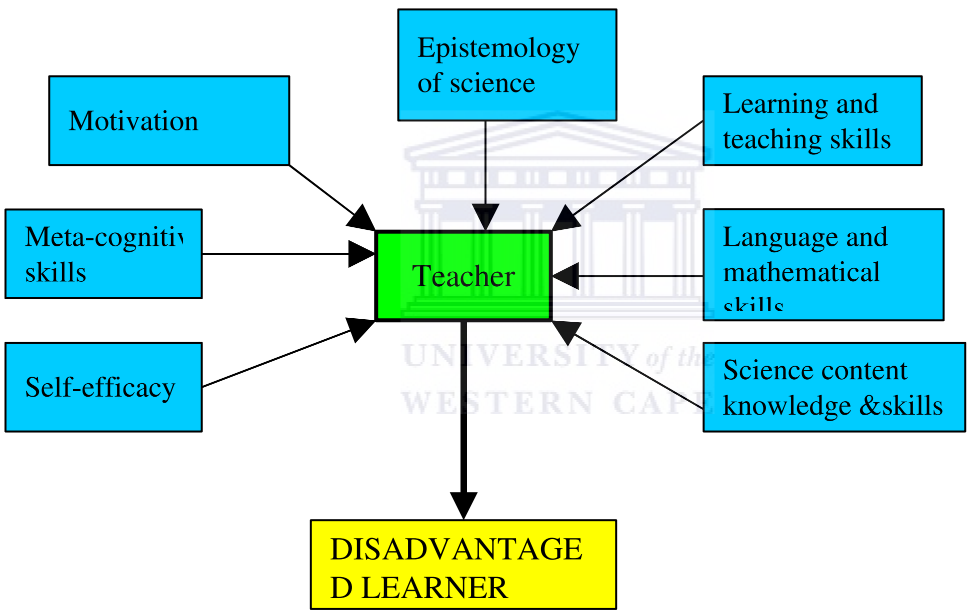

Fig. 8.1 Recommendation for improving teacher training courses for science teachers

The proposal above emerges out this study and is meant to take into account possible poor teaching in earlier years among secondary school students. What is proposed in the diagram is that teachers have to learn how to motivate their students, how to teach metacognitive skills and how to build self-efficacy beliefs of their students. Teachers have to assess the epistemological beliefs of their students and seek to change them where these impede science learning. In addition to the foregoing skills, teachers have to learn teaching and learning skills, language and mathematical skills and science content knowledge and skills. The multi-dimensional concept of learning implies that the teacher of disadvantaged students has to do more than communicating science content to students.

5. Students should be encouraged and assisted in taking over responsibility for their studies. The culture of dependency that colonial experience has created among students should be replaced by one of self monitoring and regulation in learning.

8.5 Conclusion

This study set out to determine the factors that keep students who are offered places in secondary school on merit, from performing according to expectations of teachers and educational administrators in Malawi. The constructivist perspective that formed the overall theoretical indicates that personal involvement and initiative, students' beliefs about science and science learning are critical to success in learning. The study sought to investigate the status of personal initiatives, epistemological beliefs and degree of acceptance or denial of responsibility for academic performance among secondary class 3 students in Malawi and to determine the extent to which the students regulate their learning. Interviews and survey questionnaires were used in collecting data. It was found that besides holding dysfunctional beliefs, the students had limited knowledge of learning skills and strategies. The students seem to be typically unconcerned about their performance in spite of the long history of failure in national examinations in the sciences. In some school students were not even aware of performance of students in physical science in the past year. It may as well be that deficiencies in students' knowledge and use of learning skills, their lack of awareness of the need to assume responsibility for their learning and their positivistic beliefs about science and learning science are significant factors in determining success in science learning.

One observation, however, does not prove a point in science, there is need for replication of the study in Malawi and in other nations that have similar problems. The inquiry into what students actually do after classes, however, offers fresh perspectives to the problem of poor performance in science among highly selected students. The findings of this study need to be supported results of similar studies done in country that are experiencing the problem of poor performance of highly selected students.

8.6 Limitations of the study

The limitations of the study are threefold: theoretical framework; nature and timing of the study. The possible effects of these aspects of the study on the conclusion presented previously are discussed next.

8.6.1 Theoretical framework

Constructivism, as stated in chapter one of this thesis is the overarching theoretical framework for this study. Teaching of science subjects in Malawi is hardly informed by informed by tenets of constructivism. Much of the teaching and learning of science subjects emphasizes acquisition of factural knowledge rather than development of understanding of scientific concepts. This begs the question of the utility of a study that uses an alien theoretical framework as it were, to study a contextualized national problem. The use of the constructivist theoretical framework becomes even more problematic when it is realized that many teachers in secondary schools in Malawi are unqualified, classes are large, teaching and learning materials are often not available and students are not motivated to learn science. It is possible that students' modes of attribution and learning styles are consequences of limitations of their learning environment and not the result of students' unwillingness to assume responsibility for their learning. Factores that affect students' learning are interdependent and any attempt to study one or some of them in isolation as this study attempts to do is bound to lead to unrealistic conclusions. The value of the study, nevertheless, lies in binging to the fore, students' conceptions science and science learning and what they do after classes, as one of the important factors that affect students' performance in national examinations.

8.6.2 Nature of the study

The problem under investigation has in the past been attributed to teaching and learning in primary schools. It is generally accepted in education that what happens at a lower level affects outcomes at subsequent levels. The present study has been limited to secondary class 3 students. There is no doubt that the study's findings would have been more convincing if data from primary schools were included.

8.6.3 Timing of the study

The duration of the study coincided with times of sudden changes in science policies in Malawi. Some schools stopped offering physical science before the study commenced but started teaching it again at the beginning of 2002. The sudden changes of policy that occurred during the duration of the study created an environment of uncertainty and have affected students' responses to the questionnaires. Students in some schools for example, complained that time allocated to physical science was inadequate for them to learn the subject effectively. Further investigation of this complaint reveal that some schools were allocating the subject two teaching periods per week in spite of the fact that the Ministry of Education had asked schools to revert to the usual five periods per week.

The findings and conclusions of this study should be tempered the limitations presented in the foregoing paragraphs.

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Appendix A: Piloted questionnaire on learning strategies

LEARNING STRATEGIES IN PHYSICAL SCIENCE QUESTIONNAIRE

I am finding out what you think or feel about various things concerning learning Physical Science. The purpose of my study is to improve the teaching and learning of Physical Science in secondary schools.

Please help me to know what we need to do to improve learning in Physical Science by completing the attached questionnaire.

The questionnaire is not a test. There are no right or wrong answers. All that is required is your opinion. Tick the appropriate box.

Name.......................... School...........................

1. **SEX** Female [ ] Male [ ] **2. AGE ……………** years

Please tick the appropriate box to indicate your opinion. The first one has been done to show you what you should do.

	Strongly disagree	Disagree	Not Sure	Agree	Strongly agree
Science is bad	[ ]	[ ]	[ ]	[ ]	[ ]

The person who ticked in the box below "strongly agree" felt that science was not good. They may have been thinking about the bad things of science.

Try this one yourself	Strongly disagree	Disagree	Not Sure	Agree	Strongly agree
Science is bad	[ ]	[ ]	[ ]	[ ]	[ ]

Page 1 of 4

		disagreeStrongly	Disagree	Not Sure	Agree	Strongly agree
1.	I worry a great deal about tests.	[ ]	[ ]	[ ]	[ ]	[ ]
2.	After studying Physical Science I ask myself questions to make sure I know the material I have been studying.	[ ]	[ ]	[ ]	[ ]	[ ]

3.	When I am studying, I try to put together the Information from class and from the Physical Science book.	[ ]	[ ]	[ ]	[ ]	[ ]
4.	Compared with others in the Physical Science class, I expect to do well.	[ ]	[ ]	[ ]	[ ]	[ ]
5.	I do the work in the Physical Science class because I want to understand the ideas.	[ ]	[ ]	[ ]	[ ]	[ ]
6.	When I take a test I think about how poorly I am doing.	[ ]	[ ]	[ ]	[ ]	[ ]
7.	I work on practice exercises and answer end of the chapter questions in Physical Science book even if I do not have to.	[ ]	[ ]	[ ]	[ ]	[ ]
8.	It is hard for me to decide what the main ideas are in when I study Physical Science.	[ ]	[ ]	[ ]	[ ]	[ ]
9.	I do the work in the Physical Science class because I want to do well in tests.	[ ]	[ ]	[ ]	[ ]	[ ]
10.	I am certain that I understand the ideas taught in Physical Science.	[ ]	[ ]	[ ]	[ ]	[ ]
11.	During a test, I often find that I cannot remember the facts I have learned.	[ ]	[ ]	[ ]	[ ]	[ ]
12.	Before I begin studying Physical Science, I think about the things I need to do to learn.	[ ]	[ ]	[ ]	[ ]	[ ]

		disagreeStrongly	**Disagree**	**Not Sure**	**Agree**	**Strongly agree**
13.	When I study Physical Science, I put important ideas in my own words.	[ ]	[ ]	[ ]	[ ]	[ ]
14.	I do the work in the Physical Science because the teacher is good to me.	[ ]	[ ]	[ ]	[ ]	[ ]
15.	I expect to do well in Physical Science.	[ ]	[ ]	[ ]	[ ]	[ ]

16.	It is those students who have ability to do well, that do well in Physical Science tests and examinations.	[ ]	[ ]	[ ]	[ ]	[ ]
17.	I work hard in Physical Science even if the topic is difficult to me.	[ ]	[ ]	[ ]	[ ]	[ ]
18.	When I study for a test in Physical Science, I try to remember as many facts as I can.	[ ]	[ ]	[ ]	[ ]	[ ]
19.	I do the work in the Physical Science class because it is important in the career I would like to follow.	[ ]	[ ]	[ ]	[ ]	[.]
20.	Compared with others I think I am a good Physical Science student.	[ ]	[ ]	[ ]	[ ]	[.]
21.	Even if one makes a great effort to do well in Physical Science, without ability to do well, he or she cannot do well in tests and examinations.	[ ]	[ ]	[ ]	[ ]	[.]
22.	Even when a topic is dull and uninteresting, I keep working until I understand it.	[ ]	[ ]	[ ]	[ ]	[.]
23.	When studying for a Physical Science test, I practice saying the important facts over and over to myself	[ ]	[ ]	[ ]	[ ]	[ ]
24.	I do the work in the Physical Science class because I like to appear capable to my friends.	[ ]	[ ]	[ ]	[ ]	[.]
25	I am sure I can do very well in problems and exercises assigned in the Physical Science class.	[ ]	[ ]	[ ]	[ ]	[ ]

		disagreeStrongly	Disagree	Not Sure	Agree	Strongly agree
26.	When I am studying Physical Science, I usually	[ ]	[ ]	[ ]	[ ]	[ ]

	think of my own examples of ideas covered.					
27.	When studying Physical Science, I try to connect the new ideas with related ideas that I already know.	[ ]	[ ]	[ ]	[ ]	[ ]
28.	I am satisfied with the grades that I get in Physical Science.	[]	[ ]	[ ]	[ ]	[ ]
29.	When I am studying Physical Science, I usually make mental pictures in my head.	[ ]	[ ]	[ ]	[ ]	[ ]
30.	Compared with those of other students in the Physical Science class, my study skills are better.	[ ]	[ ]	[ ]	[ ]	[ ]
31.	When I am studying Physical Science I usually ask myself questions	[ ]	[ ]	[ ]	[ ]	[ ] [.]
32.	I know that I will be able to learn the material in physical science.	[ ]	[ ]	[ ]	[ ]	.. [ ]
33.	When studying Physical Science, I often draw diagrams.	[ ]	[ ]	[ ]	[ ]	[ ]
34.	Compared with other students I think I know a great deal of Physical Science.	[ ]	[ ]	[ ]	[ ]	[ ]
35.	When studying Physical Science I try to make everything fit together.	[ ]	[ ]	[ ]	[ ]	[ ]
36.	When studying Physical Science, I make fresh notes.	[ ]	[ ]	[ ]	[ ]	[ ]

Appendix B: Questionnaire that was used to collect data in the study

LEARNING BELIEFS AND PRACTICES QUESTIONNAIRE

I would like to find out what you think or feel about various things concerning learning Physical Science. The purpose of my study is to improve the teaching and learning of Physical Science in secondary schools.

Please help me to know what we need to do to improve learning in Physical Science by completing the attached questionnaire.

The questionnaire is not a test. There are no right or wrong answers. All that is required is your opinion. Write your name, school and your age in years in the spaces provided, and tick the appropriate box.

Your responses to this questionnaire will be kept confidentially and will not be communicated to unauthorized persons.

Name.. School....…………........................

1...........................SEX Female [ ] Male [ ] **2. AGE** years

Please tick the appropriate box to indicate your opinion. Below is an example on what you should do.

	Strongly disagree	**Disagree**	**Not Sure**	**Agree**	**Strongly agree**
Science is bad	[ ]	[ ]	[ ]	[ ]	[√]

The person who ticked in the box above under the "strongly agree" column felt that science was not good. They may have been thinking about the bad things of science.

Try this one yourself	Strongly disagree	Disagree	Not Sure	Agree	Strongly agree
Science is bad	[ ]	[ ]	[ ]	[ ]	[ ]

Page 1 of 4

Please turn over the page and tick the appropriate box to indicate your opinion in questions 1-31.

		disagreeStrongly	Disagree	Not Sure	Agree	Strongly agree
1.	Slow learners cannot succeed in learnIng Physical Science.	[ ]	[ ]	[ ]	[ ]	[ ]
2.	Most words have one clear meaning.	[ ]	[ ]	[ ]	[ ]	[ ]
3.	Facts of science do not change.	[ ]	[ ]	[ ]	[ ]	[ ]
4.	Only students, who have ability to do well in Physical Science, do well in the subject.	[ ]	[ ]	[ ]	[ ]	[ ]
5.	Scientists are born with the ability to do science.	[ ]	[ ]	[ ]	[ ]	[ ]
6.	I can depend on the facts in the prescribed textbooks for Physical Science for the rest of my life.	[ ]	[ ]	[ ]	[ ]	[ ]
7.	Scientists can get to the truth if they just keep searching for it.	[ ]	[ ]	[ ]	[ ]	[ ]
8.	Knowledge of science is best characterized as isolated facts.	[ ]	[ ]	[ ]	[ ]	[ ]

9.	The best way to learn science is to memorize facts and principles of science.	[.]	[ ]	[ ]	[ ]	[ ]
10.	I am certain that I can understand the ideas taught in Physical Science.	[]	[ ]	[ ]	[ ]	[ ]
11.	Successful students of Physical Science take a short time to learn anything in the subject.	[ ]	[ ]	[ ]	[ ]	[ ]
12.	You will get confused if you try to combine new science ideas with your own ideas.	[ ]	[ ]	[ ]	[ ]	[ ]

		disagreeStrongly	Disagree	Not Sure	Agree	Strongly agree
13.	Scientific knowledge is an accurate and objective description of reality.	[ ]	[ ]	[ ]	[ )	[ ]
14.	One's ability to learn Physical Science is fixed at birth.	[ ]	[ ]	[ )	[ ]	[ ]
15.	What you learn in Physical Science depends on teachers of the subject.	[ ]	[ ]	[ ]	[ )	[ ]
16.	Scientific knowledge changes with time.	[ ]	[ ]	[ ]	[ ]	[ ]
17.	When learning Physical Science I look for the facts given by the teacher.	[]	[ ]	[ ]	[ ]	[ ]
18.	My work in Physical Science is sufficiently challenging to enable me to learn the subject.	[ ]	[ ]	[ ]	[ ]	[ ]
19.	Working hard on difficult problems in Physical Science pays off only for good students.	[ ]	[ ]	[ ]	[ ]	[ ]
20.	Almost all the information you can learn from a chapter of a Physical Science textbook, you will get during the first reading.	[ )	[ ]	[ ]	[ ]	[ ]
21.	Even if one makes a great effort to do well in Physical Science, without ability to do well, he or	[ ]	[ ]	[ ]	[ ]	[ ]

	she cannot do well in the subject.					
22.	Good students of Physical Science do not have to work hard to do well in the subject.	[ ]	[ ]	[ ]	[ ]	[ ]
23.	Those who fail Physical Science examinations are lazy.	[]	[ ]	[ ]	[ ]	[ ]
24.	I am satisfied with the learning skills that I use in learning Physical Science.	[ ]	[ ]	[ )	[ ]	[ ] [.]
25.	I am sure I can do very well problems and exercises found in the prescribed textbooks for Physical Science. .	[ ]	[ ]	[ ]	[ )	[ ]

		disagreeStrongly	**Disagree**	**Not Sure**	**Agree**	**Strongly agree**
26.	If a person tries very hard to understand a problem they will most likely end up being confused.	[ ]	[ ]	[ ]	[ ]	[ ]
27.	Every student is capable of doing very well in Physical Science.	[ ]	[ ]	[ ]	[ ]	[ ]
28.	Successful students of Physical Science learn by heart notes given to them by their teachers.	[ ]	[ ]	[ ]	[ ]	[ ]
29.	Only gifted students can succeed in difficult learning tasks in Physical Science.	[ ]	[ ]	[ ]	[ ]	[ ]
30.	I do sufficient work in Physical Science to do very well in the subject.	[ ]	[ ]	[ ]	[ ]	[ ]
31.	I can do very well in Physics and Chemistry at university level.	[ ]	[ ]	[ ]	[ ]	[ ]

THANK YOU VERY MUCH FOR COMPLETING THIS QUESTIONNAIRE

Appendix C: Free Response questionnaire

LEARNING AND EXAMINATION RESULTS EXPECTATIONS QUESTIONNAIRE

1. In the space provided please indicate the grade you think you are most likely to achieve, in each subject, in the forthcoming Malawi School Certificate Examinations next year. If you do not know the grade you are likely to achieve, indicate this by writing the abbreviation "DNK" against the appropriate subject.

Subject	Likely grade
English	……………
Chichewa	……………
Geography	……………
History	……………
Bible Knowledge	……………
Biology	……………
Physical Science	……………
Mathematics	……………
Agriculture	……………

2. What if any, are the greatest obstacles to your doing very well in physical science? Write your answer in the space provided

…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………

3. What other things about learning physical science would you like us to know?

…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………

THANK YOU VERY MUCH FOR COMPLETING THIS QUESTIONNAIRE

Appendix D: Initial Interview Protocol

1. Are you satisfied with the teaching and learning of physical scince in this school?

2. In your class there are students who do very well in physical science and other students who do not do so well. What do you think brings about this difference in performance?

3. What do you do to learn physical science after classes?

4. What grade at MSCE examination do you think you would easily achieve?

5. If you were given a chance to choose another school where you would go to complete your studies and sit for the MSCE examinations next year, what are the things you would look for in making your choice?

Appendix E: Final Interview Protocol

1. What is science to you?

2. Have you carried out any investigation in physical science this term?

3. If yes, explain the investigation you have done.

4. How do you learn physical science after classes?

5. When you were learning about the kinetic theory of matter, what do you think you really learned?

6. What helped you in learning of the kinetic theory of matter?

7. What hindered your learning of kinetic theory of matter?

8. How do you know that you learned the theory?

9. Do you know the prescribed textbooks for physical science? If yes name them.

10. What is your goal or aim in learning physical science?

11. Do you find physical science easy or difficult

12. What makes it easy or difficult to you?

13. How should science be taught to make it interesting to you?

Appendix F: Application for permission to carry out the study

UNIVERSITY OF MALA WI

PRINCIPAL

Francis Moto B.Ed., M.A., Ph.D.

CHANCELLOR COLLEGE

P. O. Box 280, Zomba,
MALAWI,
SOUTHERN AFRICA
Tel: 011 (265) 524222
Telex: 44742

CHANCOL MI
Fax: 011 (265) 524 046
Email
cats@chanco.unima.mw

Our Ref.:
Your Ref.:

22nd April, 2003

The Secretary For Education
Ministry of Education and Culture
P/Bag 328
Capital City
Lilongwe 3

Dear Sir,

PERMISSION TO CARRY OUT RESEARCH ON POOR PERFORMANCE IN SCIENCE IN SCHOOLS IN MALAWI

I write to ask for permission to carry out research on poor performance of students in science. The Principal of Makerere College and his Staff noted this problem for the first time when they administered entrance examinations to secondary school students at Blantyre Secondary School in 1942. The Headmaster of Blantyre Secondary School confirmed the existence of the problem in the same year when he administered Junior Certificate Examinations to his students. In 1945 Makerere Staff found that all the students at Zomba Catholic Secondary School failed the entrance examinations because they were all weak in science and Mathematics. More recently the Malunga Commission found that more students expect to fail Physical Science than Mathematics. This is strange, since examination results have consistently shown that performance of students is poorer in Mathematics than in Physical Science. It is suspected that one of the causes of the problem is the shortage of science teachers that the country has experienced since the colonial times. The study seeks to find how this shortage has affected:
(i) students' conceptions of science;
(ii) learning strategies used by students when learning science; and,
(iii) teachers' operational beliefs when teaching Physical Science.

The schools that have been selected for participation in the study are

Three students from each of 15 schools will be interviewed. The interview data will form the basis for a questionnaire on science and study strategies that will be administered to 1,200 students drawn from the 15 schools. There will also be 30 classroom observations using the science-learning schedule attached. It is hoped that the study will generate information that will enable teacher trainers to improve the teaching of learning strategies in schools in Malawi.

I enclose a full research proposal which has been approved by the University of Western Cape for your perusal.

Yours faithfully,

Emmanuel Dzama

Appendix G: Letter from the Ministry of Education granting me permission to conduct the research

Telegrams: MINED LILONGWE *In reply please quote*

No.:......................

Telephone: (265) 789 422 MINISTRY OF

EDUCATION, SCIENCE AND

Fax: (265) 788 064/184

TECHNOLOGY

PRIVATE BAG

328

Communications should be addressed:

The Secretary for Education, Science and Technology

CAPITAL CITY

LILONGWE 3

MALAWI

DP2/ 13 *112* / 5

23 May 2003

Mr. E.N. Dzama

Chancellor College,
P.O. Box 280,
Zomba

Dear Mr. Dzama,

RE: REQUEST FOR PERMISSION TO CARRY OUT RESEARCH IN SCHOOLS

Thank you for the request you made to carry out a scientific research in our schools.

Permission is herewith granted to you to do the research. Since the selected schools cover the entire country, there is need for the Divisional Managers in the Six Education Divisions to be informed accordingly so that they can inforn1 the heads of the schools you have selected for your study.

In this respect I wish to ask you to provide the list of schools to all the Division Managers. By copy of this letter, all the Six Education Divisional Managers are requested to inform heads of the selected schools to assist and cooperate with the research team.

Yours sincerely,
J.B. Kuthemba Mwale PhD.
For: **SECRETARY FOR EDUCATION, SCIENCE & TECHNOLOGY**

CC: All Managers

Appendix H. Samples of responses from Divisional Education Managers.

Note that the names of the schools have been deleted

Ref. NO: CEED/3/19 6th September, 2004.

FROM : EDUCATION DIVISION MANAGER (CED)
P/BAG 233,
KASUNGU.

TO **:** THE HEADMASTER, SECONDARY SCHOOL

THE HEADMASTER, SECONDARY SCHOOL

TRE HEADMASTER, SECONDARY SCHOOLS

RE: PERMISSION TO CARRY OUT RESEARCH IN SCHOOLS

Reference is made to the attached letter from director for Planning Ministry of Education Headquarters Ref No. DP2/13/12/5 granting Mr. Dzama Permission to carry out research in some selected secondary school.

You may wish to be informed that your school is one of those schools in our division which has been selected for the above underlined subject. Mr. Dzama intends to carry out a research on the learning and teaching of Physical Science at your school.

It is my sincere hope you will assist and co-operate with him accordingly.

G.S. CHIMWALA

FOR: EDUCA TION DIVISION MANAGER *(CED)*

FROM: THE EDUCATION DIVISION MANAGER (CW),
P.O. BOX 98, LILONGWE

TO: THE PRINCIPAL, CHANCELLOR COLLEGE,
P.O. BOX 280, ZOMBA

ATTENTION: **MR. EMMANUEL DZAMA - SENIOR LECTURER IN PHYSICS EDUCATION**

Dear Sir,

RESEARCH IN SECONDARY SCHOOLS ON SCIENCE LEARNING AND TEACHING

With reference to your letter dated 6th June, 2003 on the above subject, Mr. **Emmanuel Dzama**, is welcomed in the Division Education Office in the following Secondary Schools:

The necessary assistance will be provided.

N.B.S. BANDA

FOR: EDUCATION DIVISION MANAGER

Appendix I: Example of an unedited interview transcript

Rs: My name is Emmauel Dzama what is your name?

St: My name is Steve Momba.

Rs: Steve I will ask you a few questions first of all, what is science to you?

St: In science we do more concentrating we are look at things which were created or may be are not created we do look at things which are living and non living.

Rs: What is the purpose of looking at these things?

Ts: The main purpose is to know the mechanism of why these things are appearing and where they come from.

Rs: I see does science have anything to do with our lives?

St: Yes, it does.

Rs: In what way?

St: Because in most cases we hear about what causes a ma to be in this earth surface or we do hear that the earth is round so we all learn what actual made the earth to be round so in so doing science I think has to do with us.

Rs: I see! In your learning of physical science have you carried out any science investigation?

St: Yes.

Rs: What investigation have you done?

St: We carried out investigation about the force of gravity.

Rs: What did you say about force of gravity. What did you find out about the force of gravity.

St: We have found out that the force of gravity is the pushing of the earth. It is the earths magnet.

Rs What investigation did you carry out on this investigation?

St: We investigate that the force of gravity can act on any object and that the force of gravity is constant anywhere.

Rs: Is this something you did in physical science this term?

St: Not this term.

Rs: Not this term?

St: yes

Rs: What have you done this term?

St: this term we were dealing with calculations.

Rs: Of what?

St: Moles and moralities, the Avogadro's constants and the motions kinetic motion.

Rs: Did you carried out any titration's?

St: Titration's? Yes.

Rs: What did you titrate?

St: Titrate, we were trying to find out about the bromine test and also looked at methods of sep'arating things of or substances.

Rs: What do you use when titrating do you use burrets or do you have burrets there?

St: Actually on titrations we were just given some notes.

Rs: You were just given notes. You did not do anything? You did not titrate anything. You did not fill a burett and titrate to find the end point of reaction.

St: That time we do and we were looking at phenolphthalein and hydrochloric acid.

Rs: So what did you do?

First of all we had two beakers and on that two beaker we has some hydrochloric acid in a beaker and on the other beaker we had some phenolphthalein solution and we, then we add a certain indicator to see if the colour would change and the colour changes represents whether the. Our aim was to know whether the two beakers what we add was hydrochloric acid.

Rs: I see.

Rs: when you want to learn physical science on your own after classes what do you do?

St: After classes?

Rs: Where do you study?

St: At the hostels.

Rs: Is that a good enough place to study?

St: No it is not.

Rs: Why is it not a good place?

St: Because it is fond of noise.

Rs: What do you do about that noise?

St: Actually it is very difficult to control a large number of people so if the noise has become greater I just leave the place and go back to classrooms. I just go and study physical science because.

Rs: What is it that there is noise? Do people not want to study?

St: what normally happens is that at this school we do come at different reasons or purposes. There are others who just come and just play, they do not study or neither enter into our classrooms.

Rs: Oh.

St: There are some who also that.

Rs: They just stay in the hostels?

Rs: when you are studying what do you do?

St When I am studying I have the book, which I want to study. Then I have a certain plain paper and a pen and I will read and I will pick some main points and write them on my plain paper.

Rs: when you are studying the teachers' note, you also write?

St: Yes I do.

Rs: Why?

St: Because sometimes back I mean previously It was found that I would read the whole book but at last memorizing nothing so I knew that this is not study this is like reading like I am reading a news papers study it should be something which is taken serious so 1- should write some points on a separate paper so that I must have checked and trying on myself to realize those main points.

Rs: what do you think would happen if you did not take notes?

St: If I.do not take notes, I think I can pass but I can't go further to the extent I want.

Rs: Oh, I Se, You have said that you also have teachers notes.

St: Yes.

RS : What is your view about this do you think it is good for teachers to give notes?

St: aaa yes, it is good.

Rs: Why

St: Because there are some students who are poor in listening. They can't know more just when listening to what the teacher is talking about but when they read they understand more.

Rs: Can't those students read the books?

St: Yes they can but at this school the books are insufficient.

Rs: The books are insufficient? Oh, what do you do when the books are insufficient?

St: At this point in time we just share each other books in the library in the limited days for one to have books in the library is only 3 days.

Rs: Is the library open everyday?

St: Not everyday.

Rs: When is it opened?

St: its opened on Sundays, Wednesdays and Fridays.

Rs: Sunday at what time?

St: Sunday starting from 1:30 pm up to 5:00pm. But sometimes it may be opened during lunch hours starting 12 up to 1:30.

Rs But I hear that after the midterm it has been closed. Is that right?

St: Yes.

Rs: Why?

St: It is because the books are not well arranged and luck of politeness on students because there are some students who just steal some library books.

Rs: Oh

St: So the library is trying to maintain the books before they open it again.

Rs: I see, this learning of physical science apart from making notes are there other things that you do?

St: No.

Rs: You do not do other things.

Rs: When you were learning the kinetic theory of matter. Did you learn the kinetic theory of matter?

St: We did not learn about it but I studies it.

Rs: You study it?

St: Yes.

Rs: What does it say.

St The theory states that matters is made up of molecules and that molecules are made up particles and that atoms are the smallest particles of matter, they can not be created or destroyed.

Rs: Does the word kinetic meaning anything to you? Kinetic theory is there anything in common?

St: No.

Rs: In learning the kinetic theory of matter, what helped you in your learning?

St: In my learning I know how things were, how things are and how to calculate some smaller things like the relative atomic masses of some other molecules and I also learnt more about the difference between liquids, solids and gasses.

Rs: What helped you learning there? Was there anything that you think helped you to understand better.

St: Yes there was something because previously we did not know how water changed into gases form but when I study that kinetic theory of matter, I know how things from one state to another.

Rs: Was there anything that hindered- made it difficult for you to understand?

St: It was just the word "kinetic"

Rs: Nothing hindered.

Rs: How do you know that you leant the theory?

St: That I learnt it?

Rs: Yes, how do you know that you learn the theory?

St: Ok, Because we were given some syllabuses by our teacher.

Rs: I se, perhaps lets put the question this way when you were learning a topic how do you know that you have learnt it sufficiently to move on to the next topic?

St: Ok, in order for me to know that I have covered, there are some books at the library on which they have just asked question on a certain topic for example hey can just ask question on how to calculate moles. So when I study and after I know that, I have now finished I go to those books and try to answer some of the questions then I will expose them to the teacher to mark if I have got them right.

Rs: Yes, if today I say go to the hostel get me your exercise book. Shall I find evidence of questions you have answered on your own?

St: Yes.

Rs: Of questions that you have answered on your own that your teacher did not assign?

St: Yes.

Rs: I see.

Rs: The other thin is the prescribed books that you are supposed to use. Do you know them?

St: Aano.

Rs: How do you practice if you do not know the books?

St: It is because when I go to the library, I just forgot the books which are in the physical science because we have got the syllabus and in the syllabus we are told that we have to know more about the kinetic theory of matter. You have to know \ bout such things, so when I go to the library I look for the books in which I can find more information.

Rs: Now, what books do you use that are in the library?

St: Ok, we use the, we have got the books of GCEs chemistry and we have got Keith Wallis books! and 2 and we have got understanding in the world of science certain books which is also out there.

Rs: I see, now, what is your goal what do you want to do in life?

St: In my life my main goal is that I want to go to the College of Medicine to become one of medicines, to study medicine.

Rs: What do you think is going to take you there?

St: It is if I can pas Mathematics and Physical Science mostly concerned with science subjects.

Rs: What grades do you think you need to achieve to get there?

St: Mostly I think I should have distinctions either a 1 or a 2 because we are many of us who are intending to go to that college so for me to achieve my goals I think I should have grades 1 or 2.

Rs: Were there people from this school who were admitted to Medical College?

St: Not at all.

Rs: Last year no one was.

St: No one was.

Rs: Why, do you think what was he reason?

St: It is because of poor practice, Lack of materials in this school.

Rs: So how do you plan to get over those problems?

St: First I tries my best to meet the teacher if I have read a certain topic in the book and find it complicated. In that they are talking about a certain experiment which is need to be taken I visit the teacher and consult them that I have found this and I want to try to check if this is true then if acceptable I g and investigate by doing the experiment.

Rs: Have you done such a thing before?

St: Yes.

Rs: What did you do?

St: We have a certain experiment on an egg. To take the bottle, an empty bottle either of coca-cola and right up some fire the bottle and take a boiled egg, remove the shell and put it on top of the bottle and while the fire is still lighting or burning we let the egg for almost 15 minutes and our observations was that we found that the egg was squeezed into the bottle.

Rs: When did you do this?

St: It on this term before the mid term holiday.

Rs: That was a simple experiment done at Junior Certificate so did you have to d at MSCE?

St: Because I read a certain book on this MSCE and I find it. I also believe trying to investigate.

Rs: Oh, I see, Now do you find physical science easy or difficult?

St: It is easy, unless it is ....

Rs: What makes it easy?

St: Because most of the times it deals with things that we can see with our eyes. Things that are visible.

Rs: Are you able to see electrons and protons?

St: No those are invisible, but somehow like the force of gravity acts and change and look at organic chemistry how substances react with a certain metal.

Rs: Yes, I was asking this because science deals with things that are invisible. Would you agree with that?

St: Yes I agree.

Rs: When you are learning physical science here, do you think this is an ideal environment for you to learn physical science?

St: Yes it is.

Rs: It is, but you have just said there is noise in the hostels.

St: There is noise but the headmaster tries is best to minimize he noise.

Rs: Now, how about he laboratories are they good enough?

St: No, they are not good enough.

Rs: what is The problem there?

St: Lack of learning materials.

Rs: What are the learning materials that are not there?

St: The microscopes which are available are just few, some of the gases are not available.

Rs: These things why are they not available?

St: I do not know the aim why they are not available.

Rs: Are there things to do with teachers teaching. Are you satisfies with the teaching?

St: Teaching materials?

Rs: No the actual teaching.

St: Teacher are available.

Rs: But I have just been told that there wee no teachers here for.....

St: Ok, teachers are, especially in MSCE we have, got only a single teacher who teaches physical science.

Rs: How about learning, are you learning sufficiently to be able to take the examination next year?

St: Not at all.

Rs: What are the things that are making it ......

St: Ok, because once the teacher is ill, definitely that day we are not going to learn physical science and I remember a certain teacher taught me that physical science should be practiced everyday to get it right.