EFFECTS OF TEACHING LEARNING SKILLS: COMPARISON OF RESULTS OF TWO ANALYSIS METHODS

M. ED. (TESTING, MEASUREMENT AND EVALUATION)

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DECLARATION

I the undersigned hereby declare that this thesis is my own original work, which has not been submitted to any other institution for similar purposes. Where other people's work has been used acknowledgements have been made.

PHINOCE YOHANE KUOPSYA

Full Legal name

Signature

Date

CERTIFICATE OF APPROVAL

The undersigned certify that this thesis represents the student’s own work and effort and has been submitted with our approval.

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DEDICATION

To my wife, Philliner Chienda and my dear three children; Victor, Naomi and Precious, I dedicate this thesis for their understanding of temporary suspension of some basic family needs and my absence during the study.

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ABSTRACT

This study was undertaken to determine the effect of teaching learning skills on achievement level of students in senior secondary physical science. It compared analysis of covariance (ANCOVA) and independent sample t-test on the residualized gain scores, as methods of data analysis in the study. The study further investigated the relationship between age/gender and the achievement level in the subject and explored the extent to which, students use learning skills. Two hundred and twenty form three students from four secondary schools selected from Central Eastern Education Division (CEED) were used. A quasi-experimental design was used and eighty-two girls and one hundred and thirty-eight boys sat for physical science pre and posttests. Further, twenty boys and twenty girls completed a Motivated Strategy for Learning Questionnaire (MSLQ).

ANCOVA showed that there were statistically significant differences in the achievement level between the experimental and the control groups at alpha level of 0.05. This implied that the intervention improved the performance of the experimental group. ANCOVA and independent sample t-test on the residualized gain scores yielded similar results except for the effect size (ES) which was lower for the ANCOVA. Partial correlation coefficients between the achievement scores and age showed that the effects of the intervention were age dependent. Younger students gained more from the exposure to the learning skills than their older counterparts. However, point biserial correlations between achievement scores and gender showed weak correlations. Generally, there were no significant differences in the achievement levels based on gender. Chi square test of homogeneity on the responses to the MSLQ showed that there were statistically significant differences between the experimental and the control groups in their use of learning skills.

The study concluded that the teaching of the learning skills improved achievement level of students in senior secondary physical science. Generally, ANCOVA and an independent sample t-test produced similar results and could be used when analyzing data in quasi-experimental studies. The effects of the intervention are age dependent while gender has little influence on the achievement level. However, the intervention affects how students use learning skills when learning senior secondary physical science. The details are presented in the study.

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LIST OF ACRONYMS AND ABBREVIATIONS

ANCOVA Analysis of covariance

ANOVA	Analysis of variance
B. Ed	Bachelor of Education
B. Sc	Bachelor of Science
CASE	Cognitive Acceleration through Science Education
CDSS	Community Day Secondary School
CEED	Central Eastern Education Division
CTT	Classical Test Theory
Dip. Ed	Diploma in Education
EDM	Education Division Manager
ES	Effect Size
FPE	Free Primary Education
IRT	Item Response Theory
MANEB	Malawi National Examination Board
MSCE	Malawi School Certificate Examination
MSLQ	Motivated Strategies for Learning Questionnaire
MURDER	Mood, Understand, Read, Digest, Expand and Review
PIF	Policy and Investment Framework
PSQ5R	Purpose, Survey, Question, Read, Recite, Reduce, Reflect, and Review.
SQ4R	Survey, Question, Read, Recite, Reflect, and Review
SQ3R	Survey, Question, Read, Recite, and Review
S-R	Stimulus – Response
TDC	Teacher Development Centre

UCE	University Certificate of Education

CHAPTER 1

1.1 Introduction

This study was prompted by the continued persistence of the problem of poor performance of students in sciences in general and physical science in particular in Malawi. It was further prompted by the problem of having no validated standard for data analysis when assessing whether there are differences between two groups in quasi-experimental studies. Like in many other developing countries, science education is given a high priority in Malawi because it is perceived as an important tool in the national development agenda, (Mbano 2001; Yoloye 1998). There is a wide spread agreement that expansion of scientific knowledge and technology is necessary for national development (Ministry of Education, Sports, and Culture Malawi Education Sector: Policy & Investment Framework, 2001). It is important to address this problem of poor performance in sciences if the nation is to be developed.

There has been an array of studies in Malawi on the problem of poor performance in physical science. These studies have explored factors that contribute to the problem of students' poor performance in the subject (Kamwendo, 1984; Dzama, 1984; Kunje, 1988; Mitchell, 1993 and Dzama, 2007a). On the other hand, there also have been a number of experimental and interventional studies aimed at improving performance level of students in the subject in Malawi. Such studies have concentrated on the teaching side of the teaching – learning equation, (Chikoko, 1988) and on the use of a specific interventional program, (Mbano, 2001). Studies that have attempted to improve performance of students in sciences have not resulted in better pupil performance. These studies are discussed briefly in the following paragraphs.

Chikoko (1988) attempted to address the problem of poor performance in physical science by finding the teaching method, which improves performance level of students in the subject. She found that guided discovery approach was a better teaching method, which improved performance level of students, more than expository methods. Mbano (2001) in her study addressed the problem of pupils' poor performance in science in Malawi by attempting to improve students' reasoning ability using the Cognitive Acceleration through Science Education (CASE) intervention program. She found that experimental boys performed better in science, mathematics, and English than the control boys on a national examination one year later after the intervention.

In support of Chikoko's (1988) and Mbano's (2001) findings, research studies conducted elsewhere provide evidence that teaching of learning skills improve performance level of students. For example, Cao and Nietfeld (2007) assert that promoting student's meta-cognitive learning strategies may enhance academic performance. Zion, Michalsky and Mevarech (2005) showed that students improve their learning outcomes if they are provided with meta-cognitive guidance. Rozencwajg (2003) in her study concluded that teaching meta-cognitive strategies to poor students would be one way of improving their level of academic performance. Grayson (1996, 1997) refers to underachievers as underdeveloped students. She says that the solution to the problem of students' underdevelopment is to present both science content and learning skills to the underdeveloped students. It is further believed that such cognitive strategies as rehearsal, elaboration and organizational strategies foster active cognitive engagement in learning and results in higher levels of achievement (Weinstein & Mayer, 1988).

This study endeavored to find out whether the teaching of learning skills would affect achievement levels of students in senior secondary school physical science in Malawi. It also aimed at comparing the results of the study obtained from the use of two statistical methods of data analysis; Analysis of covariance (ANCOVA) and independent sample t–test on the residualized gain scores, when analyzing data. In the course of determining the effects of teaching students the learning skills and the comparison of the two analytical methods, the study also sought to examine the extent to which use of learning skills is affected by age and gender of the students.

In this study, it was hypothesized that:

- There will be no significant differences in the performance level of students, who are taught learning skills and those not taught the skills in physical science.
- There will be no differences between the results obtained using ANCOVA and those obtained using independent sample t–test on the residualized gain scores.

- There will be no significant relationship between use of learning skills, and achievement levels of students on one hand and age or gender of the student on the other.
- There will be no significant relationship between exposure to learning skills and use of learning skills when learning physical science.

Comparison of performance level of the experimental and the control groups in experimental studies pose a question of whether the observed differences, if any, are not due to preliminary group differences or due to the error in the method used during data analysis. Attribution of the differences in the performance level to the intervention need to be backed and justified by the method used for data analysis. Previous interventional studies used ‘independent sample t–test on the residualized gain scores’ (Mbano, 2001) and a ‘2 x 3 analysis of variance’ (Chikoko, 1988) when analyzing their data. This study will use two statistical methods of analyzing the same data to determine whether there are differences between the two groups (experimental and control groups) in their achievement levels after the intervention. In order to increase precision of the results of the study and reduce the error variance, two methods of reducing preliminary group differences were followed. These methods are briefly discussed in the following section.

The first method was by using a research design, which reduces preliminary group differences. This was done through matching process during sampling of the schools involved in the study. Cohen and Manion (1989) say that:

> The equivalence of groups can be strengthened by matching, followed by random assignment of experimental and control treatments….matching could be on social-economic background of pupils, school size, organization and teaching methods (Cohen & Manion, 1989, p.199).

Mbano (2001) used the method of matching the selected schools during sampling in the process of controlling for preliminary group differences. Her study matched schools on boarding/day, urban/rural and government/private status. In the current study, the two groups; experimental and control groups were matched on school size (three streamed), organization (Government co-education boarding), and teaching method (guided discovery method). This was done to reduce effects of preliminary group differences on the achievement level of students after the intervention.

The second method of validating the results used a statistical method, analysis of covariance (ANCOVA), which reduces error variance and increases the power of the test. The statistical control and an explanation of the variations between the two groups; experimental and control groups, was done by using analysis of covariance. ANCOVA was used to partition out the effects of extraneous variables and preliminary group differences from the effects of the intervention. Mbano (2001) used residualized gain scores to counter the use of non-randomized participants. The two methods; ANCOVA and Independent sample t–test on the residualized gain scores, were used because they minimize the effects of not using randomized allocation of participants.

1.2. Background and history

The problem of poor performance in sciences in Malawi has a long history. For example, Chipembere (2002) noticed the problem of poor performance in sciences in Malawi in 1964. He commented how Malawian students were performing compared to Tanzanians as he says:

> Many years later, I was to notice that Tanzanians did much better than Malawians did in mathematics and science in the Cambridge Overseas School Certificate Examinations (Chipembere, 2002 p.73).

He perceived the differences in the performance level in sciences between the students in the two countries when he moved from Tanzania to Malawi. His observation was that Malawian education was then preferred to a Tanzanian education. He however later discovered that Tanzanians were performing better than Malawians were in mathematics and science in the Cambridge Overseas School Certificate.

Chikoko (1988) also noticed the problem of poor performance in physical science in Malawi in her study where she was comparing two teaching methods in the subject; guided discovery and expository method. She quotes the Malawi National Examinations Board, MANEB, that:

> Achievement in physical science at the Malawi Schools Certificate Examinations (MSCE) level over the past years has not been up to the expected standards. A downward trend of poor performance has been observed in this subject especially from 1981 to 1985 at distinction and credit levels (Malawi National Examinations Board, MANEB, 1987 cited in Chikoko, 1988 p.1).

In the same context, Mbano (2001) observed that in 1994 the failure rate was higher in physical science (27%) than in other subjects such as in English, which had a failure rate of 8% in the Malawi school certificate national examinations. She postulated that poor performance in sciences had transformed into fear of failing science among students in Malawi. The problem of poor performance is depicted in the following extract:

> For example in 1994 only 76% of pupils in government secondary schools sat for physical science on the Malawi school certificate of education (MSCE) examinations. In addition, pupils do more poorly in science than in other subjects; for example, in 1994 27% failed physical science in comparison to 8% failing English at the MSCE level (Mbano, 2001 p.19).

Mbano cites two major problems in sciences in Malawi; the general low performance and the lack of higher order thinking skills. The two major problems as cited by Mbano, (2001) might have a causal relationship in students' failure. Lack of higher order thinking skills may have been causing the general low performance of students in the subject. Mbano (2001) suggested that 'the problem of science in Malawi would require tackling issues of policy, teacher education, assessment, curriculum and pupils cognitive levels and learning strategies.' This study attempted to tackle the problem of poor performance from the learning point of view.

Dzama (2007a), commenting on the same problem of poor performance in physical science said that:

> The average failure rate in physical science increased from 31% between 1984 to 1993 to 41% between 1999 and 2003 (Dzama, 2007a p.192).

The Government of Malawi perceives the role of education to be of national development and believes that only an educated populace would effectively realize Malawi's rich natural resources base. These sentiments are expressed in the following statement:

> The broad policy of the Malawi Government is to alleviate poverty. Education is the centerpiece of this policy (Ministry of Education, Sports, and Culture Malawi Education Sector: Policy & Investment Framework, 2001 p.6).

Malawi's national development agenda would be hampered unless the main constraints facing the education system are addressed. The three main challenges facing Malawi's education system are access, equity, and quality. It had been observed by the government that the quality of education provided by the education system in Malawi was declining, (Ministry of Education, Sports, and Culture Malawi Education Sector: Policy & Investment Framework, 2001). The government planned to introduce innovative ways of teaching such as resource based learning (open learning) and study circle learning by the beginning of 2002 to improve quality of education provided in schools (Ministry of Education, Sports and Culture Malawi Education Sector: Policy & Investment Framework, 2001).

An educated populace in general and an expansion of scientific knowledge and technologies in particular are considered as prerequisites to national development. (Ministry of Education, Sports and Culture: Malawi Education Sector: Policy & Investment Framework, 2001). However, there is as previously stated, a problem of poor performance in sciences in Malawi (Case, 1968; Kamwendo, 1984; Dzama, 1984; Kunje, 1988, Mitchell, 1993 and Dzama, 2007a).

The problem of poor performance in Malawi's education system in general is reflected in the Policy and Investment Framework. Under quality, it is commented that:

> The consequences of this situation are that the quality of education provided by the system has deteriorated to a disturbing level (Ministry of Education Sports and Culture Malawi Education Sector: Policy & Investment Framework, 2001 p.12).

The situation being referred to in this section is the introduction of free primary education (FPE), which resulted in the shortage of basic physical, and human resources, high pupil/qualified teacher ratio, scarcity of basic learning materials and poor terms and conditions of employment for teachers. Poor performance has been a concern to educators, ministry of education and the government of Malawi. There are indications that performance in sciences has deteriorated to a disturbing level. This study seeks to identify ways and means of improving performance in science.

1.3 Motivation for the study

I came to appreciate the magnitude and significance of under achievement in 2001 when I started working as an assistant examiner (marker) in MSCE physical science. At the end of each marking session, examiners are required to discuss and report on the performance of candidates. During such discussion sessions from 2001 to 2006, the examiners kept on talking about the problem of poor performance in the subject. During this period, examiners were citing poor English, illogical presentation of facts, poor manipulative and diagramming skills, and lack of practical skills as factors that contribute to the problem of poor performance. As a physical science teacher for over 10 years, I developed an insight into the difficulties that students experience when learning physical science. In the year 2002, I suggested development of an MSCE questions and model answers booklet in an attempt to solve the problem of poor performance in the subject. The suggestion was to include explanations to the answers on how the answer had been arrived at. This was actually an attempt to assist students learn physical science on their own and at the same time, assist them in the process of problem solving. The suggestion was sent to Chancellor College publications for consideration. Chancellor College Publication engaged me as one of its sciences article writer. This gave me an urge to search more on whether there could be a way of improving performance in the subject.

1.4 Factors contributing to the problem of poor performance in sciences

The problem of poor performance in sciences is not unique to Malawi; it is also a problem in other African countries. The following section briefly discusses some of the major factors that contribute to the problem of poor performance in the subject. Studies done in Malawi in particular and Africa in general are discussed.

1.4.1 Use of inappropriate learning skills

The first factor, which contributes to the problem of poor performance in sciences in Africa, is the use of inappropriate learning styles (Grayson, 1996). Derry and Murphy (1986) define learning skills as mental tactics employed by an individual in the process of learning, which facilitate effective acquisition of knowledge. Mayer (2002) defines a learning strategy as cognitive processing performed by the learner at the time of learning that is intended to improve the learning. A learning strategy is a group of learning skills, which are used to facilitate acquisition of knowledge or skill. It is known that different types of concepts in physical science require different learning strategies if the concepts are to be learnt effectively. When students are using inappropriate learning strategies, learning of the prescribed concepts and principles is not effectively done. Dzama (2007a) found that the problem of poor performance in physical science in Malawi is perpetrated by the fact that students in Malawi mostly use two learning skills; reading and listening. The use of these two learning skills only, would not facilitate effective acquisition of other types of concepts and skills, which may demand other learning skills such as elaboration and problem solving skills.

1.4.2 Language of instruction

The second factor, which contributes to the problem of poor performance in science, is the language of instruction. Case (1968), in her study of language barrier in science teaching in Malawi, found that language of instruction affects performance level in sciences. In the same context, Grayson (1996) summarized factors that contribute to the problem of poor performance in sciences in African countries. She observed that inadequate background in the language of instructional delivery affects performance level in sciences. Physical science in Malawi is taught in English. If a student is not conversant with the language of instructional delivery, as already stated, the grasping of concepts becomes difficult.

1.4.3 Mismatch between the level of cognitive development and the cognitive demands of science syllabus

The third factor mentioned by Grayson (1996) as a contributor to the problem of poor performance in sciences is the absence of prerequisite cognitive skills in the learners. Cognitive skills deal with mental processes such as thinking, memory, and problem solving. Tolman (1948) investigated cognitive processes in learning by studying how rats learn their way through a maze. He found evidence that rats formed a cognitive map or a mental map of the maze early in the experiment, but did not show their learning until they received reinforcement for completing the maze. Modern cognitive psychologists believe that learning involves complex mental processes, including memory, attention, language, concept formation, and problem solving. In cognitive learning, the focus of teaching is on the creation of learning situation whereby the learner is encouraged to take an active role and use appropriate learning strategies. The findings of Dzama (2007a) that most of our students use only two learning strategies; reading and listening and that student's lack planning and monitoring of their own work begs the question of whether teaching the students learning skills would affect their performance level in senior secondary physical science. Grayson (1996) suggests that the presentation of both the content and learning skills would be one way of solving the problem of underachievement in students.

1.4.4 Absence of meta-cognitive learning skills

The fourth factor relevant to this study, mentioned by Grayson (1996), that also affects performance level of students in sciences in Africa, is the absence of meta-cognitive awareness. Meta-cognition is the process of thinking about thinking. Flavell (1983) describes meta-cognition as one's knowledge concerning one's own cognitive processes or anything related to them. Meta-cognition can be defined as the ability to know what we know and what we do not know. It is the ability to develop a plan of action, maintain that plan in mind over a period, then reflect back on it and evaluate the plan at completion of the task. Meta-cognition can be categorized into three components; meta-cognitive knowledge, meta-cognitive awareness and meta-cognitive control (Baird, 1990).

Meta-cognitive knowledge refers to knowledge of one's own thinking process (Cao and Nietfeld, 2007) and concerns the knowledge of the nature of learning. In a classroom setting, Metacognitive knowledge allows students to become aware of what they know and what they do not know about a certain topic. This deals with effective learning techniques and personal learning characteristics. Meta-cognitive awareness can be defined as one's knowledge of the nature of the learning task one is undertaking and the process being made in the course of learning. Meta-cognitive control deals with decisions taken about approaches to learning, process made, and learning outcomes that are aimed at maximizing achievement. Metacognitive skills refer to intentional regulation of study strategies (Cao & Nietfeld, 2007). During a learning process, metacognitive skills allow students to select an appropriate strategic intervention, monitor the execution of the strategy, and evaluate its effectiveness.

According to Grayson (1996), if a student is not aware of the nature of the learning task and the processes needed in order to learn the given task, such a student is unlikely to succeed in his or her learning. Dzama (2007a) observed that lack of planning and self-monitoring of students' own work as a contributing factor to the problem of poor performance in physical science. Planning and monitoring of one's own work falls under meta-cognitive control. This means that lack of meta-cognitive control affects achievement negatively.

1.4.5 Negative attitude towards physical science

Kamwendo (1984) explored factors that adversely affect the performance of Malawian girls in Malawi Junior certificate physical science examinations. He found that negative attitude towards physical science contribute to the problem of poor performance in the subject. The low performance of girls was attributed to the negative attitude towards the subject among other factors.

1.4.6 Lack of teaching and learning materials

Literature also points to lack of material resources for science learning and teaching as another factor that contribute to the problem of poor performance in the subject. Physical science is a practical subject, (Dzama, 1984). The concepts of the subject in most cases need to be proved or worked out through experiments in order to be properly understood and internalized. The practical work requires material. In the absence of materials, teaching and learning become ineffective. In Malawi, most of the community day secondary schools (CDSS) do not have equipment for teaching physical science. The teaching of physical science is mostly theoretical. This implies that the teaching methods used are usually teacher centered which does not promote active learning in the subject among students (Chikoko, 1988).

1.5 Interventional studies to improve performance in physical science

There has been an attempt in Malawi and in other parts of the world to try to solve the problem of poor performance in science subjects and in physical science in particular. The following section briefly discusses some of the quasi-experimental and interventional studies, which attempted to seek possible solutions to the problem of poor performance in the subject. In addition, this section discusses methods of data analysis used in these studies.

Studies done in Malawi by Chikoko (1988) and Mbano (2001) have shown that performance in the subject can be improved.

Chikoko (1988) in her study of effects of two teaching strategies (guided discovery as opposed to expository approach) and teachers' qualifications on form three students' achievement in physical science used a quasi-experimental approach to determine effects of teaching strategies on achievement. She compared students taught using guided discovery with those taught using expository methods. Intact classes taught by subject teachers were selected for the study. A 2 x 3 analysis of variance was used to analyze the data. In order to compare pretest and the posttest scores, data was computed using Wilcoxon matched-pairs signed-ranks test. The results showed that guided discovery, as a teaching strategy is more effective for teaching physical science than expository approach. Mbano (2001) in her study of exploring the use of CASE intervention program in secondary school classes in Malawi showed that the effects of the intervention study had age and gender interaction effects. Data was analyzed using 'independent sample t–test on the residualized gain scores.

Research studies conducted elsewhere provide evidence that teaching the students meta-cognitive learning strategies can improve their performance level (Cao & Nietfeld 2007;

Rozencwajg, 2003). Zion, et al (2005) found that providing Meta-cognitive guidance also improves students' performance.

1.6 Learning, learning skills and learning strategies

Learning is a process of constructing meaningful representations, of making sense of one's experiential world (von Glasersfeld, 1996). Learning could be defined as the process of getting to know and understand ideas and concepts to the extent of correctly using the acquired knowledge in different situations. Learning strategies refer to any behaviors or thoughts that facilitate encoding in such a way that knowledge integration and retrieval is enhanced (Weinstein & Mayer, 1988). A learning strategy can be defined as a general way or procedure or a framework of approaching how to learn ideas or concepts. It could be thought of as a sequential learning structure designed to take the learner through in the process of acquiring particular types of ideas, skills, concepts, principles, and scientific rules. Different learning strategies have varied processes and demands different activities in the process of learning. It implies that a learning strategy is a generalized learning process, which could be used in learning a set of different but similar concepts. For example, for a student to learn what is supposed to be learnt in a given topic, he/she needs first to know the objectives of the topic. Then the student has to choose a way of tackling the content of the topic. One way of tackling the content is to use a study strategy designated as SQ3R. SQ3R stands for Survey, Question, Read, Recite, and Review. The student has to survey the topic first by going through the chapter, looking at the headings, sub headings, the summary, and the end of chapter study questions. The second step is to ask oneself questions. Usually the questions are the conversions of objectives of the topic. The third step is to read the topic, section by section while looking for the answers to the questions. The fourth step is to recite whatever has been read especially the main ideas in the topic. The fifth step is to review the chapter to understand the ideas, which were not understood in the first reading. Ones' use of a series of learning skills to achieve a certain learning task constitutes a learning strategy.

The selection, of an appropriate learning strategy, is neither an automatic nor a rational act. It is a subjective act. The appropriateness of a learning strategy is related to the objectives of the topic. It also depends on the type of concept being learnt. However, certain strategies tend to be more associated with certain types of concepts or principles. For example, a diagram cannot be learnt through reading but one has to practice drawing it several times before it is effectively mastered.

The activities in which a student is engaged during the learning process are the learning skills. Examples of the learning skills are; making own notes, reading, rehearsing, drawing diagrams and designing mnemonics (Gettiger & Seibert, 2000).

1.7 Learning theories and learning in science

Learning can be defined in two perspectives following the two paradigms of learning theories. Learning theories are generic attempts to describe how people learn. What follows are definitions of learning based on the two perspectives; behaviorist and constructivist perspective.

1.7.1 Behaviorist perspective of learning

Behaviorists maintain that learning is developing the ability to perform new behaviors and that human learning can be explained by examining the stimuli, re-enforcers, and punishments that a person experiences (Skinner, 1953; Watson, 1913). They focus on the change that takes place in an individual's behavior**.** Behaviorist learning theory is based on animal research. Pavlov demonstrated that a dog would reflexively salivate upon hearing a bell or merely seeing him or his assistants after the dog came to associate the bell with feeding time. His discovery led to a new study called classical conditioning and later to stimulus – response (S-R) psychology. Thorndike (1928) proposed that learning is the result of associations forming between stimuli and responses. It was believed that such associations or habits become strengthened or weakened by the nature and frequency of the S-R pairings. Skinner (1953) explored the application of operant conditioning, in which learning is controlled through reinforcement of certain stimulus - response patterns. In his operant conditioning theory of learning, he observed that behaviors that were followed by reinforcement (positive reward) increase in their frequency while those that were followed by negative rewards decrease in their frequency of occurrence. The S-R framework purports that learning of ideas and concepts could be explained without referring to any unobservable internal states, and that learning is the result of operant conditioning. In this model, cognitive processes are not emphasized. The implication for instructional design in teaching and learning situations is that creation of learning activities that foster higher-order thinking skills is not emphasized.

Some of the early adversaries of the behaviorists were the Gestalt psychologists, who argued that learning involves the perception of relations among events. For example, Tolman and his associates demonstrated that learning could occur even if there is no reinforcement. They showed that rats learned to find their way in a maze quicker if they had been in the maze before, but without the reinforcement of food in the end of the maze. The following section discusses constructivists' perspective of learning.

1.7.2 Constructivist perspective of learning

Learning is a process of constructing meaningful representations and of making sense of one's experiential world. (von Glaserfeld, 1996). Constructivists study the change in an individual's knowledge, emphasizing mental processes such as thinking, memory, and problem solving. Von Glaserfeld (1996) considers constructivism to be the current dominant learning theory. The theory posits that all information a person receives must pass through the filter of his or her prior knowledge and experience. The learner then constructs knowledge from such filtered information.

1.8 Measurement theories

Classical test theory (CTT) is a body of related psychometric theory that predicts outcomes of psychological testing such as the difficulty of the items or the ability of test-takers. Item response theory (IRT) is the study of test and item scores based on assumptions concerning the mathematical relationship between abilities (or other hypothesized trait) and item responses (Crocker & Algina, 1986). IRT was introduced in 1950s as an alternative to CTT. IRT assumes that test-takers possess some amount of underlying ability or trait and relates this latent ability and item parameters to the probability of a positive response. IRT models are expressed at an item level while the CTT models are expressed at test level (Reid, Kolakowsky-Hayner, Lewis & Armstrong, 2007). IRT fit into the tradition of experimental control of extraneous variables, through statistical adjustment while CTT controls the extraneous variables through matching and randomization.

1.9 Justification of the study

Research studies, as previously stated, show that there has been a consistent trend of poor performance in physical science in Malawi (Kamwendo, 1984; Dzama, 1984; Kunje, 1988, Mitchell, 1993 and Dzama, 2007a). The studies have shown factors that contribute to the persistent problem of poor performance in the subject. The experimental studies conducted in Malawi aimed at mitigating the problem of poor performance in Physical science used varied methods of data analysis such as 'independent sample t–test on the residualized gain scores' [Mbano, 2001], Wilcoxon matched-pairs signed-ranks test and a 2 x 3 analysis of variance (Chikoko, 1988).

Apart from Mbano's (2001) and Chikoko's (1988) intervention studies to mitigate the problem of poor performance in physical science, there have been few experimental and interventional studies in the subject conducted in Malawi. Despite the frequency at which we need to analyze data to determine and compare change to ascertain differences between experimental and control groups in quasi-experimental studies, there has been no absolute standard of data analysis in such studies.

Mintzes & Wandersee (1997) have suggested that research in science education should now focus on students' learning rather than teaching. They claim that efforts to improve science teaching are rapidly approaching a point of diminishing returns and that studies should concentrate more on the learning side of the teaching-learning equation.

There was then the need to conduct an experimental and an interventional study, which would concentrate on the learning side of the teaching-learning equation and compare different methods of analyzing the data obtained from the study.

1.10 Statement of the problem

This study endeavored to address the problem of whether the teaching of learning skills would affect achievement levels of students in senior secondary school physical science in some selected secondary schools in Central Eastern Education Division (CEED) and whether the use of 'ANCOVA' and 'independent sample t-test on the residualized gain would yield similar results.

1.11 Purpose of the research

This study endeavored to determine and document; the effects of teaching learning skills on achievement levels of students in senior secondary school physical science and assess methods of analyzing data between ANCOVA and the independent sample t-test. .

1.12 Research questions

1. How would teaching students learning skills affect their performance in senior secondary physical science?

2. Would the use of ANCOVA or an independent sample t- test during data analysis produce similar results?

3. Are the effects of teaching learning skills age or gender dependent?

4. How would the teaching of the learning skills affect learning strategies used by the students in learning senior secondary physical science?

1.13 Definition of terms

The following terms are used in this study having the following meanings;

Achievement level:

The gain scores or the difference score between the pre and the posttests.

Learning skills:

A set of tactics used in the acquisition of knowledge or skills.

Meta-cognition:

Reflecting on what has been learnt through self-questioning as a process used to effectively master a specific learning task.

Meta-cognitive knowledge:

This is what allows students to become aware of what they know and what they do not know about learning a given topic.

Meta-cognitive skills:

This is what allows students to select an appropriate learning strategy, reflect on its use, and evaluate its effectiveness.

Mnemonics:

An invented combination of letters whereby each letter is a cue to or suggests of an item one needs to remember.

Multi-stage cluster sampling

A form of probability sampling whereby a sample is chosen in two or more stages, because the population cannot be easily identified or they are extremely large (Creswell, 2002).

Self-regulated learning:

Learning where learners take the active and independent role in learning.

1.14 Limitations of the study

This study was conducted within some limitations and as such, the results are valid within its premises of these limitations.

1.14.1 Learning skills used in the study

This study did not include all the learning skills that affect performance in physical science. Only those learning skills that were considered more direct to the un-mastered skills were covered. Some of the skills, which were not taught, may have been more effective in improving achievement level of the students in the subject. This may have an effect on the results.

1.14.2 Coverage of the subject content and items representativeness

The second limitation was that this study did not cover all the topics in senior secondary physical science because of limited time and financial capacity. Questions for the pre and the post achievement tests, where scores were generated for analysis, were drawn from a few topics, which were covered. This may have affected some students who might have been good at certain aspects of the untested topics thereby portraying results contrary to the findings of the study. The questions were selected from the MANEB past examination papers from 1998 to 2006. These were modified in such a way as to take into consideration of the skills, which were shown as not being mastered over the years in order to check the effectiveness of the intervention. The sampled questions may not have been a good representative of all the questions from the selected topics. However, the questions were formulated taking into account of the objectives of the topics from the syllabus.

1.14.3 The teaching of the learning skills

The third limitation is that subject teachers were teaching the learning skills as they were teaching the content of the subject. Teacher personality differences in understanding the learning skills and instructional delivery may have affected the results. However, the two teachers who were involved in teaching of the learning skills were oriented to the task in order to reduce knowledge differences in the delivery of the learning skills content.

1.14.4 Sample size and representativeness

The schools involved in this study were selected from one education division, CEED out of six education divisions. They were all co-education government boarding schools. These schools may not have constituted a representative sample of co-education government boarding schools in Malawi. However, it was assumed that the results would be valid within these limitations and that the results can be replicated by taking in more schools and other educational divisions.

1.14.5 Time taken to teach the learning skills

Some of the learning skills needed more time to be effectively mastered by the students. Due to the time available for a master's course, these kinds of learning skills may not have been properly grasped by the students and consequently not give the expected results.

1.15 Theoretical and conceptual frameworks

In education, learning theories are attempts to describe how people learn. The theories help us understand the inherent complex processes of learning. This study used constructivism as an overarching learning theory and classical test theory as a measurement theory. The study specifically used cognitive flexibility theory of learning when implementing the learning skills intervention program.

Constructivism was used as an overarching learning theory because of the increasing support it is given by modern educationists as a theory of learning. The other reason for opting for constructivism is due to the increasing criticism towards the end of the 1950s of behaviorist models. The behaviorist theory tends to exclude emphasis on mental processes when considering how people learn. On the other hand, constructivism represents a paradigm shift from education based on behaviorism to education based on cognitive theory. This study took a cognitive approach to learning. Cognitive approach was chosen because modern cognitive psychologists and educationists believe that learning involves complex mental processes, which includes memory, attention, language, concept formation, and problem solving. The study was guided by cognitive flexibility theory of learning, meta-cognitive, and self-regulated learning skills as conceptual frameworks.

CTT has been used as a measurement theory because of a number of reasons. The first reason is that the assessment instruments were developed without using IRT techniques. Reid et al (2007) comments that:

> In contrast, for assessment instruments developed without IRT techniques, meaningful interpretation of test results requires administration of the entire test and comparison of the obtained total score with the results obtained from an appropriate normative group (Reid et al 2007, p178).

The pre and the posttest, as measurement instruments, were developed without using IRT techniques and that the entire instruments were administered to get meaningful interpretations from the test results. This is in contrast with IRT whereby there is need to develop a mathematical model about the relationship between ability (trait) and performance for each individual item.

The other reason is that the theory is based on the premise that an observed score is a composite of a true and an error score (Crocker & Algina, 1986). The study design aimed at reducing the effects of extraneous valuables on the error score and partitioning out the effects of these variables. CTT provided a basis for matching some factors in the experimental and control groups that would confound the results. What follows is a brief discussion of constructivism as a learning theory and classical test theory as a theory of measurement.

1.15.1 Constructivist theory of learning

Constructivist learning theory is based on the students' active participation in problem solving and critical thinking regarding a learning activity. This learning theory perceives learning as a process in which the students actively constructs or builds new ideas or concepts by integrating their current and past knowledge about the ideas or the concepts being learnt. Ausubel (1968) asserts that, the most important single factor influencing learning is what the learner already knows. In the same context, Kelly (1995) and Piaget (1926) showed that children construct knowledge as they interact with the physical and the social world, and through everyday usage of language. A key tenet of constructivism is that learners actively construct meaning on their own (von Glaserfeld, 1995; Vygotsky, 1978; Piaget, 1926).

The implication to teachers is that they should act as facilitators who encourage students to discover principles and construct knowledge for themselves thereby solving realistic problems. The theory purports that the internalized concepts, rules, and general principles may consequently be applied in a new practical real-world context. Proponents of constructivism support the notion that knowing is an active process of constructing understanding rather than the passive receipt of information.

The following is a brief description of the conceptual frameworks; cognitive approach to studying learning, cognitive flexibility theory of learning, Meta-cognition and self-regulated learning strategies.

1.15.2 Cognitive approach

Cognitive approach to learning, studies the change in an individual's knowledge, mental processes such as thinking, memory, attention, language, concept formation and problem solving, (Wikipedia; the free Encyclopedia, undated).

1.15.3 Cognitive Flexibility Theory of learning

Cognitive flexibility theory builds upon other constructivist theories such as Bruner's' theory of instruction, Ausubels' theory of learning, and Paige's' developmental theory. Cognitive flexibility theory focuses on the nature of learning in complex and ill-structured domains (Spiro, Feltovich, Jacobson & Coulson (1992). Spiro & Jehng (1990) state that:

> By cognitive flexibility, we mean the ability to spontaneously restructure one's knowledge, in many ways, in adaptive response to radically changing situational demands. This is a function of both the way knowledge is represented, (e.g., along multiple rather than single conceptual dimensions), and the processes that operate on those mental representations (e.g., processes of schema assembly rather than intact schema retrieval), (Spiro & Jehng, 1990, p. 165).

The theory also asserts that effective learning is context-dependent, so instruction needs to be very specific. The theory is based on a number of principles that; learning activities must provide multiple representations of content, and that instruction should emphasize knowledge construction, and not just transmission of information.

1.15.4 Meta-cognition

Meta-cognition is the process of thinking about thinking. Llewellyn (2005) defines meta-cognition as awareness and regulation of ones' learning processes. Gunstone, (1994) considers meta-cognition to be knowledge, awareness, self-monitoring, and self-regulating of the learning processes. Flavell (1983) says that, meta-cognition refers to one's knowledge concerning one's own cognitive processes or anything related to them.

This study gave meta-cognitive guidance to the students in the experimental schools on planning, monitoring, and reflecting on their learning activities. For example, students were taught; planning to study a topic by first aiming at knowing the objectives, monitoring their study by using personal study time tables, using study questions, engaging them in group work, how to prepare and write examinations and reflecting on their performance after writing an examination.

1.15.5 Learning strategies

Learning strategies refer to methods that students use to learn. Learning strategies may take the form of techniques for improving memory, better studying or test-taking strategies. For example, developing mnemonics is the method of memory improvement technique; it involves making a word whereby each letter is a cue to a word that assists a person to remember. For example ROYGBIV is a mnemonic which assists in remembering the colors of a rainbow; red, orange, yellow, green, blue, indigo and violet. A typical example of a study skill program as a learning strategy is SQ3R, which suggests 5 steps: (1) survey the material to be learned, (2) develop questions about the material, (3) read the material, (4) recall the key ideas, and (5) review the material.

1.15.6 Self-regulated learning and learning skills

There are a number of definitions of self-regulated learning. Three components of the definition are important for classroom performance. The first definition includes students' meta-cognitive strategies for planning, monitoring and modifying their cognition (e.g., Brown, Brandsford, Campione, & Ferrara, 1983; Corno, 1986; Zimmerman, & pons, 1988). The second definition includes students' management and control of their effort on classroom academic tasks (Pintrich & Groot, 1990). The third definition includes the actual cognitive strategies that students use to learn, remember, and understand the material (Corno & Mandinach, 1983; Zimmerman & Martinez-Pons, 1988).

Gettinger and Seibert, (2000) said that, there are two types of learning skills; activity and regulatory control level learning skills. Activity learning skills are such as meaningful reading, making own notes, working out a mnemonic, elaborating, designing and describing an experiment and problem solving. Regulatory or control level learning skills involve controlling, planning, monitoring and reflecting on learning activities. The regulatory level learning skills constitute meta-cognitive skills (Gunstone, 1994). In this connection, students in the experimental schools were taught activity-learning skills such as using study methods like SQ3R, PSQ5R, and MURDER. The study also gave guidance on designing and describing experiments, learning diagrams, and problem solving process and the designing and the use of mnemonics as a method of memorizing information. Regulatory control level skills are the meta-cognitive skills, which were taught as outlined above.

1.16 Classical test theory

Classical test theory (CTT) is a body of related psychometric theory that predicts outcomes of psychometrical testing such as the difficulty of the items or the ability of the test-takers. The theory is based on the premise that the observed score is the sum of a true score and an error score (Crocker & Algina, 1986). CTT fits into the tradition of experimental control of variables through matching and randomization. The true score is unobservable and is a constant for a specific individual for a particular trait while the error score is a random variable. The error score is dependent entirely on the conditions under which measurements are made. It is thought be a result of a disturbance that is due to a composite of multitude of factors not controlled in the measurement procedure.

Hambleton and Jones, (1993) maintain that the major advantage of CTT is its relatively weak theoretical assumptions, which make CTT easy to apply in many testing situations. The use of CTT is also supported Lawson (1991) comparative study of IRT-based [one-parameter Rasch model] and CTT-based item and person statistics for three different data sets in which exceptionally strong relationships between IRT- and CTT-based item and person statistics were reported. Though the study was based on somewhat small data sets and only examined the most restrictive one parameter IRT model, the results suggest that information from the two approaches about items and examinees might be very much the same. 50(3): 177 – 188. Reise, Ainsworth and Haviland, (2005) say that available evidence suggests that the difference between IRT and traditional psychometric methods are not trivial. Theoretically, IRT overcomes the major problem of CTT that of its circular dependency of CTT's item/person statistics (Xitao, 1998).

1.17 The assumptions

The assumptions were that by randomly assigning schools to either the treatment or the control groups, in addition to the matching process of the schools involved at the design stage, reduction of preliminary group differences between treatment and control groups had been done. Differences which were not eliminated by the matching process and the random assignment of the schools to either experimental and control, were adjusted by the use of ANCOVA and residualized gain scores. The teaching of how to teach difficult topics in the control schools was assumed to have counteracted *Hawthorne effects* on the performance of the students in the control schools.

1.18 Synopsis of the thesis

This thesis has five chapters. Chapter one provides background information of the problem of poor performance in physical science. It also relates the attempts that have been made to alleviate the problem of poor performance in the subject. The research questions and the statement of the problem have been outlined in the same chapter.

Chapter 2 provides a review of related literature with the aim of showing the magnitude of the problem and attempts made to provide solutions to the problem. Chapter 3 provides the study strategies and the methodology used in the study. The results of the study are presented in chapter four. Chapter 5 offers a discussion of the results. Conclusions, recommendations, and suggestions for further study are presented in the same chapter.

CHAPTER 2

REVIEW OF RELATED LITERATURE

2.1 Introduction

In this chapter, related literature to the current study is reviewed. The literature has been categorized into three broad themes, namely: exploratory and interventional studies and methods of data analysis.

The exploratory studies are reviewed to provide details of the kind of problems students in Malawi and in other countries experience when learning physical science. The interventional studies are reviewed to show attempts that have been made to improve performance in sciences in Malawi and in other countries. Methods of data analysis are reviewed to strengthen the knowledge base for the dimension of the studies that compares appropriateness of statistical methods for data analysis in quasi-experimental studies.

The general purpose of the review is to provide a basis for further thinking about the problem of poor performance and to show varied methods of data analysis that have been used in the experimental studies to determine differences between experimental and control groups.

2.2 Poor performance in sciences

Exploratory studies done in Malawi and other countries have shown that performance of students in physical science has been poor, (Kamwendo, 1984; Dzama, 1984; Kunje, 1988; Grayson 1996; Dzama, 2007a). Studies done by Dzama (2007a), Kunje (1988), and Grayson (1996) will be reviewed in detail because of their relevance to the present study.

Dzama (2007a) in his study of towards accounting for poor performance in science among Malawian students explored individual learning-related factors that keep highly selected students from performing at their expected levels in national examinations. In Malawi, selection of students into a secondary school is based on merit. It would be expected that these highly selected students would be performing at their expected levels. The study set out to explore individual students learning related factors that keep these highly selected students in Malawi from performing at their expected levels. In the study, learning was investigated from both individual and social constructivists' perspective.

Dzama's (2007a) study used a mixed or a multi-methods design. The study was divided into three parts: analysis of documents and archives pertaining to the problem of poor performance in science, a questionnaire survey of science learning, and in-depth interviews of selected students about science, and learning in physical science. He used several methods of data collection such as; analysis of historical documents, records and archives; administration of a Likert-type questionnaire; administration of free response anonymous questionnaire and conducting individual and group interviews.

His sample consisted of 1303 secondary class three students. There were 725 boys and 578 girls drawn from eighteen schools randomly selected from eighty-nine Government and Government assisted secondary schools in Malawi. The students had an average age of 17.1 with a range of 23 to 13 years old.

To determine how students learn physical science, the Likert-type questionnaire was administered to all the selected students. The anonymous questionnaire was administered to all the selected students including additional 165 students. Forty students were interviewed individually and in-groups about their beliefs of science and science learning.

Data was analyzed using various methods due to the multi-methods nature of the study. The methods used were; document analysis, obtaining descriptive statistics, inductive and interpretive analysis of interview transcripts and free response questions.

The findings of the study showed that the historical problem of poor performance in the subject was persistent and it was postulated that the problem would worsen if no interventions are going to be effected. Students had high positive self –efficacy of themselves as learners of science and that they hold positivist beliefs about science and science learning.

Literature supports the position that when students are engaged in meta-cognitive activities, they succeed in academic performance. It has also been demonstrated that teaching of meta-cognitive skills and guidance in using the skills, improves performance level of the students (Cao & Nietfeld, 2007; Zion et al, 2005). Pintrich and Groot (1990) in their study of motivation and self-regulated learning components of classroom academic performance, examined relationships between motivational orientation, self-regulated learning, and classroom academic performance for 173 seventh graders from eight science and seven English classes. Their findings were that self-efficacy and intrinsic value were positively related to cognitive engagement and performance. More important to the current study is the finding that self-regulation, self-efficacy, and test anxiety are the best predictors of student performance.

Although students showed high positive self-efficacy beliefs about science and science learning in Dzama (2007a) study, they were still performing poorly in the subject. According to the results of the study, it could be argued that the problem of poor performance in the subject is due to two reasons; students being limited in their knowledge and use of learning skills and lack of self-regulated learning skills. Lack of control and management of their own studies could also be an important contributing factor to the problem of poor performance in the subjects. The other pertinent factors that contribute to the problem of poor performance in the subject are that the commonly used learning skills by the students are reading and listening (Cao & Neitfeld, 2007). There were traces of self-regulated learning, which were detected such as self-questioning about the topic one is learning among the students in the course of the study, but one student only demonstrated control and management of ones' studies (Dzama, 2007a).

The findings of Dzama (2007a) and other similar studies (Little, 1985; Mc Callum, Hargreaves & Gipps, 2000; Tsai, 2004) imply that Malawian students perform poorly due to lack of learning skills. Effective learning methods such as elaboration, visualization, making own notes, doing end of chapter exercises, drawing diagrams, problem solving and memorizing are rarely used by students in Malawi (Dzama, 2007 (a)). Literature shows that the limited learning strategy use is a factor that contributes to the problem of poor performance in the subject. For example, reading and rereading textbook chapters, the most frequently selected learning method among students (Carrier, 2003), is considered a relatively ineffective approach to learning, as it is not active (Mackenzie, 1994), involves shallow processing (Craik & Tulving, 1975), and provides no feedback (Winne & Hadwin, 1998).

The results of this study are somehow supporting the notion that Malawian students respond to questionnaires based on the socially acceptable answers and not on what is true to them. Dzama (2007a) found that students in Malawi have high positive self-efficacy of themselves as learners of science. According to Pintrich and Groot (1990), the students were supposed to display positive relationship to cognitive engagement and performance. It seems that the problem of social desirability bias in Malawi is refusing to die. Students in Malawi aim at giving socially acceptable responses to researchers rather than what is true to them. A strong social desirability bias among secondary school students in Malawi was shown in their responses to the Relevance of Science Education (ROSE) questionnaire (Sjoberg & Schreiner, 2005). Case (2004) argues that the presence of desirability bias among students weakens the use of questionnaires in determination of students' conceptions and approach to learning. She observed that most students have learned to recognize the 'right' answers in an inventory.

At the conclusion of the summary of the study of problem of poor performance in science subjects among Malawian students, prepared for the Ministry of education, Dzama (2007b) asserts that:

> For learners to become strategic in their studies, they need to have a repertoire of learning skills. Absence of knowledge of learning skills or learning 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 for students to match learning tasks to appropriate learning skills (Dzama, 2007b, p. 35).

The excerpt challenge educators to train students to be strategic in their studies by equipping them with a variety of learning skills. The absence of the knowledge of the learning skills or the learning strategies is in this case assumed as one of the causes of poor performance in physical science. It is implied that limited knowledge of learning skills is one of the factors that must be addressed to improve learning and performance in science in schools in Malawi. Cotton (1995) asserts that young students need to learn the art of learning.

Cao and Nietfeld (2007) found that college students' Meta-cognitive awareness of difficulties in learning the class content does not automatically lead to adjustment of study strategies. Their study responded to the problem of how college students' meta-cognitive knowledge relates to regulation of their study behaviors during the classroom learning process. The purpose of the study was to document difficulties that students perceive in learning class content and study strategies they subsequently select to deal with the challenges over a semester and to examine the relationship of students' awareness of the difficulties with their strategy selection and test performance.

The study addressed four research questions. The research questions were about; the difficulties students perceive in learning class content, types of study strategies students select to deal with the perceived difficulties, the relationship between the perceived difficulties and students' selection of study strategies, and the relationships between students' perceived difficulties, selected study strategies and test performance.

Their sample consisted of 94 participants (76 females and 18 males). The age range of the students who participated in the study was between 18 to 43 years with a mean age of 23 and a standard deviation of 5.98. The course was taken during the junior or senior year after admission to the teacher education program. An alternative project option was offered in lieu of the study participation. Both classes followed an identical class schedule, used the same course materials, and covered the same major topics. The classroom environment was constructed to facilitate students' reflection on achievement goals and study strategies according to their actual performance throughout the semester.

Data was collected using a monitoring worksheet. Each student completed the monitoring worksheet at the end of each class for a total of 11 weeks. Students' performance was measured by using four closed book classroom tests comprising of three quizzes and one final exam. The three quizzes consisted of 25 four optional multiple-choice questions. Each quiz covered a unit of the course content. The final exam contained 50 items of the same format. The test items either were created by the instructors or were selected from the test bank accompanying the textbook.

Data were analyzed using both qualitative and quantitative methods. The two open-ended questions were analyzed qualitatively. Responses to the two questions were transcribed verbatim and analyzed using constant comparative method. This was used to extract themes from the verbal data and to develop the profiles of students' perceived difficulties of learning the class content and the study strategies they selected to deal with the difficulties. The qualitative data was triangulated with quantitative data analysis. The quantitative data analysis procedure used a chi-square statistic to test the significant patterns among the eleven units of the data and to corroborate the profiles of students' perceived difficulties in learning the class content and the profiles of their selected strategies over the semester. The second analytical procedure was a non-parametric correlation procedure, which was used to answer the research questions concerning students' perceived difficulties, selected study strategies, and test performance.

The results were that students reported to have difficulties in understanding a particular concept and distinguishing similarity and differences between concepts. Rereading the textbook or lecture notes was the predominant strategy (66% to 94%). Though students perceived different kinds of difficulties in learning the class content, this awareness did not lead to variation in the selection of the study strategies.

The study hypothesized that the students' awareness of the different kinds of difficulties in learning the class content would influence their selection of study strategies. It was assumed that students would be selecting more sophisticated strategies such as; elaboration, self-questioning, summarization, organization, and help seeking.

The results of Cao and Nietfeld (2007) concur with those of Dzama (2007a) and other studies (Carrier, 2003; Winne & Hadwin, 1998) that have reported that students usually use reading and listening as learning strategies. It has also been observed that students' selection of study strategies is not always optimal (Perverly, Brobst, Graham, & Shaw, 2003) and that they choose strategies that would likely not promote deep processing in closed book examinations (Carrier, 2003). The results of Cao and Nietfeld (2007) and other authors have further shown that even after many years of studying in school, students are still not good at selecting appropriate learning strategies (Justice & Dornan, 2001; Presseley, Van Etten, Yokoi, Freebern, & Van Meter, 1998). Students are also not good at self-regulating their learning process (Perverly et al 2003; Presseley, Bokowski, & Schreiner, 1987). Furthermore, Cao and Nietfeld (2007), point at the discrepancy between students' knowledge of learning strategies and their use of these strategies. The current study intervened on this aspect of learning. Lack of knowledge of the use of learning skills and strategies may partly explain why students perform poorly in examinations because there are other concepts, which require other skills of learning other than reading and listening such as elaboration and problem solving. The current study's intervention was expected to equip the students with a wide variety of alternative learning skills to choose from when learning various tasks.

Weinstein and Mayer (1986) commented that different cognitive strategies have been found to foster active cognitive engagement in learning and results in higher levels of achievement. The positive indices observed by Dzama (2007a) such as high positive self-efficacy and elements of self-regulated learning should have increased performance level of the students in the subject. In one of his recommendations for further research, Dzama (2007a) cites Dart, Burnett, Purdie, Boulton – Lewis, Campbell and Smith (2000) that the teaching of learning skills has been shown in the literature to improve learning of students. He observed that the emphasis in teacher training colleges and faculties of education has been on teaching rather than learning skills. He recommended that an intervention study be carried out to determine the effect of teaching learning skills on pupils' performance in science. He further advised that such a study should control for other variables that are likely to affect its results.

The current study was based on this recommendation and seeks to find solutions to the long-standing problem of poor performance in physical science. The current study aimed at exploring whether the teaching of the learning skills would affect the choice of learning strategies which students' employ when tackling different kinds of academic tasks.

Kunje (1988) in his study of a comparison of physical science cognitive demands and pupils' cognitive ability investigated the problem of whether different school environments and the science curriculum help to promote Piagetian cognitive development in secondary school pupil in Malawi. The study also investigated the problem of mismatch between cognitive development of the students and cognitive demands of the curriculum.

Piaget's (1926) theory of cognitive development was used to measure the cognitive developmental stages of the students in the study and the cognitive demands made by the science syllabus. The study used a 2 x 2 x 2 factorial design to compare cognitive abilities of secondary school pupils.

A sample of 20 schools was randomly selected from 54 secondary schools, which were offering physical science then. There were six schools from northern, five from central and eight from the southern regions. Twenty students were selected from each school, 10 form two students and 10 form four students making 20 students from each school. A total of 121 girls and 251 boys with age range from14 to 24 of years were selected.

To compare the cognitive development of the pupils and the cognitive demands of the curriculum materials, two instruments were used; the pendulum task and the curriculum analysis taxonomy. The pendulum was administered to 20 students in each school to measure Piagetian cognitive developmental levels of the pupils and the curriculum analysis taxonomy was used to measure Piagetian cognitive demands of the various curriculum materials.

A three-way analysis of variance of data was done to test the differences in cognitive development to the formal level between form two and form four pupils, and between boarding and day secondary school pupils. A chi square statistic was used to test the differences between the cognitive demands of the curriculum materials and the cognitive ability of pupils.

The results showed that there is a difference between cognitive ability of the students and the cognitive demands of the curriculum materials. It was also observed that the social environment necessary for cognitive development in boarding secondary school may not be different from that encountered at the day secondary school. The study suggested that the future physical science curriculum should consider including what would assist in pupils' cognitive development. It was further proposed that a further research be conducted which would bring to light the factors which retard the cognitive development necessary for positive learning outcomes in physical science in Malawi.

The results of his study are important because they have enlightened the current study that cognitive development of students is a pertinent factor in students' performance. It has been argued that the problem of poor performance in physical science may be due to the mismatch between the cognitive demands of the curriculum and the cognitive development of the students. This argument may be true considering that some students may not have attained formal operational thinking even when their age is at that level.

The solution to the problem of mismatch between the cognitive demands of the syllabus and the cognitive ability of the students would be as Grayson (1996) suggests that is to present both the content and the learning skills to the students. Mbano (2001) and Dzama

(2007a) support the findings of Kunje (1988). The problems of poor performance seem to lie on the lack of cognitive learning skills.

2.3 Performance differences in sciences based on age and gender of the students

Kamwendo (1984) explored factors that would suggest reasons as to why girls perform poorer than boys in the subject. Differences were explored between girls and boys in terms of their attitudes towards physical science, job relevancy, class participation, sex bias, readability of Junior Certificate physical science textbooks, teachers' expectation, participation in scientific activities at home and subject difficulty. This study used a sample of 129 Junior Certificate students, (76 boys and 53 girls), seven physical science teachers and seven head teachers drawn from the seven secondary schools from the southern region of the country. He used three questionnaires to explore how pupils perceived physical science and how they participated in the learning process of the subject.

The study showed that more girls had negative attitude toward physical science than boys did. Kamwendo's (1984) findings concur with those of Fraser (1982) who asserted that:

> The relationship between attitudes and achievement is that students who are more satisfied (have positive attitude) with science lessons, other things being equal, ought to be among the ones most successful academically (cited in Kamwendo, 1984, p.16).

The excerpt above implies that those students who have negative attitude towards the science lessons would be unsuccessful. It could be argued that if girls have negative attitude towards physical science then they would not be successful in the subject. In the same context, Stoyle (1983) argues that boys tend to perform better than girls because boys develop more positive attitude than girls towards spatial motor and linguistic skills, both important in the study of sciences. He asserts that there is a direct relationship between attitude and achievement.

Kamwendo's (1984) study further found that jobs preferred by girls did not demand a lot of physical science knowledge. In addition to this, girls were found to participate less in class activities than boys did. Furthermore, their textbooks were more biased towards boys. It was also found that the activities of boys at home mostly required scientific principles as opposed to those of girls.

The study confirmed that the performance of girls was lower than that of the boys in the subject. His study supported earlier research studies, which showed that the performance of boys was better than that of girls, (Keeves, 1973; Finn., Dulberg & Reis, 1979). Dzama (1984) in a study of factors affecting the attainment levels of students in the Malawi certificate of Education physical science examinations found that younger students are more likely to do well in physical science than older students are.

2.4 Interventional studies to improve performance in physical science

Research studies done in Malawi and elsewhere show that performance of students could be improved. . Interventional and experimental studies done by Mbano (2001), Chikoko (1988) and Cao and Nietfeld (2007) will be reviewed in details to show efforts to improve performance in the sciences and the methods used during data analysis.

Mbano (2001) carried an intervention study of exploring the use of CASE intervention program in secondary school classes in Malawi. The study addressed the problem of pupil's poor performance in science in Malawi by attempting to improve student's reasoning ability using the CASE intervention program.

The CASE intervention program is based on Piaget and Vygotsky's cognitive development theories. It is designed to accelerate cognitive development of pupils from the concrete stage to the formal operations stage.

The study addressed four issues; the implementation of CASE in the Malawian situation, whether there is a critical period for cognitive acceleration, the role of meta-cognition in CASE and an investigation of classroom interaction in CASE lessons.

The study used a quasi-experimental design with intact classes in four experimental and four control schools. The schools were matched for characteristics such as whether they were government or mission schools, boarding or day, and urban or rural. The sample comprised of 425 students (148 girls and 277 boys).

Data were analyzed using two statistical methods; residualized gain scores and chi square statistic. Residualized gain scores were used because as Borg and Gall (1989), and Campbell and Stanley (1963) say that residualized gain scores take into account the effects of starting levels of pupils on the gain students make during the period of the implementation of the intervention. Comparisons of performance level between experimental and control groups in experimental studies need to be justified. The differences, if any, between the two groups; experimental and control could be because of preliminary group differences or because of the methods of data analysis used in the study. In order to eliminate these preliminary group differences and accredit the differences in the performance levels to the intervention, statistical procedures, which take into account the effects of starting levels of the pupils assist in attributing the differences to the intervention. One of such procedures is the use of independent sample t-test on the residualized gain scores.

The study used teaching and learning materials developed by the CASE program in UK. Trained teachers taught lessons every fortnight for 2 years. The teachers and students in the experimental schools were given some materials while nothing was done in control schools except for the pre and posttest administrations. Members of the research team were visiting the schools at least twice a year.

The results showed that experimental boys performed better in science, mathematics, and English than control boys in national examinations one year late after the intervention. The other finding was that there was no evidence of the existence of the critical period for cognitive acceleration. The results also showed that the intervention showed gender and age interaction effects. Her findings have shown an important aspect of the effects of an intervention program that there is a need to consider gender and age interaction on academic achievement in Malawi. The current study endeavored to determine whether there are gender or age dependent effects of the teaching of the learning skills.

Kunje (1988) found that the senior science curriculum had higher cognitive demands than the cognitive abilities of the students. Other studies show that most of the science taught in secondary schools requires formal operational thinking (Shayer & Adey, 1981). In the same context, Shayer, Kuchemann, Wylam (1976) also found that a small proportion of students in secondary schools had been shown to have a formal operational thinking. The fact that most of the science taught in secondary schools needs formal operational thinking and that low proportions of the students have the formal operational thinking may also explain why there is poor performance at the level. It has been argued that the mismatch between the cognitive demands of the physical science syllabus and the cognitive ability of the students learning the subject could be one of the major factors contributing to the problem of poor performance in the subject. Mbanos' (2001) study was a response to the previous studies, which suggested development of students' cognitive levels in order to improve performance level of the students in the subject. The results were rather disappointing in that it seems that the intervention was age and gender biased. It favored boys and younger students.

Chikoko (1988) in her study of the effects of two teaching strategies and teachers' qualifications on form three students' achievement in physical science compared two teaching strategies: the expository approach and the guided discovery approach. The study also examined the influence of teacher qualification on students' academic achievement.

The study used a quasi-experimental design in that it used intact classes, which were taught by the teachers selected for the study. The overall research design was a 2 x 3 factorial design. Her sample consisted of 24 purposively sampled physical science teachers selected from ten government secondary schools in the southern region. Twelve teachers formed the experimental group and the remaining twelve teachers formed the control group. The teachers were classified into three groups; teachers with Diploma in Education, teachers with a Bachelors of Education and teachers with Bachelors of Science plus a University Certificate of Education (UCE). A total of 1270 form three boys and girls participated in the study. The experimental group was taught using guided discovery approach. In this group, students were divided into small groups of four or five. Each group was given a handout of details of the experiments to be performed during the study including all the necessary materials. Teachers were guiding the students when they were not sure of what to do during the lessons. Group two used an expository approach. The teachers used lecture and demonstration methods of teaching. The teachers were demonstrating the experiments to the students. The lessons in this case were teacher centered. Students were not given the handouts concerning the experiments for the study.

The instrument used to collect data was an achievement objective-type written test, which had thirty-two multiple-choice questions. The researcher, basing on the MSCE physical science objectives and other resources, developed this instrument. Data were analyzed by using a 2 x 3 analysis of variance. There were two independent variables; teaching strategies (guided discovery approach and expository approach) and teacher qualifications (Dip. Ed., B.Ed., and B.Sc + UCE). In order to compare pre test and the posttest scores, data were computed using Wilcoxon matched-pairs signed-ranks test.

The results of the study were that; the treatment had a significant influence on the performance of the students and that guided discovery is more effective for teaching the MSCE physical science syllabus. Teachers' qualifications play a role in influencing students' academic achievement and that, teachers with higher academic knowledge in science and with proper professional training have a better command in teaching physical science.

2.5 Statistical methods used when analyzing data

2.5.1 Analysis of covariance

Lord (1967) showed that where it is not possible to allocate people into conditions randomly, which means that the initial scores for the two groups may differ, t-test on the gain scores and ANCOVA partialling out the initial scores can lead to different conclusions. This is an often-discussed paradox in psychology and education (Wright, 2006). Wright (2006) further says that the two most common statistical approaches are doing a t-test on the gain scores and an analysis of covariance (ANCOVA) partialling out the initial scores. Lord (1967) showed that these alternatives could lead to different conclusions.

Analysis of covariance is a statistical method of data analysis that combines regression analysis and analysis of variance. It is used to increase the power of the test and reduces error variance. Hinkle, Wiesma, and Jurs (1994) recommend the use of ANCOVA and maintain that:

> Controlling and explaining variation in the dependent variable can be accomplished with either experimental control by using research design or statistical control by using analysis of covariance (Hinkle et al, 1994 p. 484).

Borg and Gall (1989) also support the use of analysis of covariance in controlling variance they maintains that;

> The main threat to the internal validity of non-equivalent control – group experiments is the possibility that group differences on the posttest are due to preexisting group differences rather than to a treatment effect: Analysis of covariance...is frequently used to handle this problem. Analysis of covariance reduces the effects of initial group differences statistically by making compensating adjustments to the posttest means of the two groups (Borg & Gall, 1989 p. 683).

The two scholars above show that in order to reduce the effects of initial group differences when applying experimental methods to educational problems, posttest means need to be adjusted for prior differences.

Creswell also comments on the use of analysis of covariance in the following statement;

> To equate the characteristics of the groups, experimental researchers may use a pretest… Because pretests may affect other aspects of the experiment, they are often statistically controlled using procedures of covariance rather than simply comparing them with posttest scores (Creswell, 2002, p. 318-319).

Both Hinkle et al (1994) and Creswell (2002) agree that in order to control and explain variation in the achievement scores, both experimental (using research design) and statistical control (using analysis of variance), should be employed. Pretest scores are used as a covariate. Cohen and Manion (1989) support the use of pretest scores as a covariate as they say that;

> ANCOVA is a powerful statistical procedure, which uses a pretest mean scores as a covariate to control for initial differences between experimental and control groups on a number of independent variables (Cohen & Manion, 1989, p.197).

Cohen and Manion (1989), Hinkle et al (1994) and Creswell (2002) support the use of ANCOVA and pretest mean scores as a covariate to control and adjust for preliminary group differences between the experimental and the control groups in experimental designs. This study used ANCOVA as a means of partitioning out the initial group differences to effectively, measure the effects of the intervention.

2.5.2 Assumptions of ANCOVA

There are two major assumptions that underlie the use of ANCOVA:

1. An assumption of linearity between the covariate and the dependent variable
2. An assumption of parallelism or homogeneity of regression

ANCOVA has to be used on condition that the assumption of linearity is rejected and we fail to reject the assumption of parallelism.

2.5.3 Independent sample t-test

Another statistical method used to counter the use of non-randomized participants is the use of independent sample t-test on the residualized gain scores. Residualized gain scores take into account the starting levels of the participants. Mbano (2001) comments on the use of residualized gain score that;

> Residualized gain scores take into account the effects of starting levels of the pupils on the gain students make during the period of the implementation of the intervention (cited in Mbano, 2001 p.122).

Mbano [2001] used residualized gain scores in her study where she addressed issues like; the implementation of CASE in the Malawian situation, whether there is a critical period for cognitive acceleration, the role of meta-cognition in CASE and an investigation of classroom interaction in CASE lessons. The method was used to counter the effects of use of non-randomized assignment of participants to treatment groups.

2.6 Conclusion

The chapter has provided details of the kind and the nature of the problem students in Malawi face when learning physical science and efforts of improving performance level of students in the subject. It has also shown different methods of analyzing the same type of data from quasi-experimental studies. The exploratory studies have shown that the kind and the nature of the problems that Malawian students face are not different from other students in other countries. What might differ is the magnitude of the problem.

The interventional studies have shown that performance can be improved in physical science. Literature has also shown that certain teaching methods (e.g., guided discovery methods) and engagement into active meta-cognitive learning strategies would be the solution to the problem of poor performance in the subject. However, efforts to improve performance in physical science have not been exhaustive. This study was an attempt to find a solution to the problem of poor performance in physical science and find a better method of analyzing the data from quasi – experimental designs.

CHAPTER 3

RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

This study determined the effects of teaching learning skills on students' achievement level in senior secondary school physical science and assessed methods of analyzing data from the quasi – experimental designs. The first chapter has presented the research questions and the theoretical framework guiding the study. Related literature has been reviewed in the second chapter. The review of the literature had two main aims: to provide insights on the nature and severity of the problem of poor performance in physical science and to discuss and assess the methods used during data analysis and their effects of remedial efforts reported in the literature.

This chapter presents the research design of the study and the strategies used to determine the effects of teaching learning skills on achievement level of students in the subject and compare methods of analyzing data to determine differences between experimental and control groups in quasi experimental designs. The following sub-topics of the study are discussed in the chapter; research design, the research strategies, sampling procedure, data collecting instruments, development of data collecting instruments, data collection, data analysis, and ethical issues.

3.2 Research design

This study used a quasi-experimental design because it used intact classes. This design was used because for ethical reasons it was not possible to randomly assign students to either experimental or control groups. A number of similar education experimental and interventional studies have used this design to establish cause and effects (Mbano, 2001; Chikoko, 1988). Creswell (2002) also recommends the use of this design.

The study involved physical science classes of four intact schools of which two schools were randomly assigned as the experimental group and the other two as the control group. Students in the two experimental schools and the two control schools formed single groups respectively. This was done because it was deemed not convenient to artificially create groups for the study since this would have disrupted learning in the schools. Quasi-experimental design was suitable for the study since classes were randomly assigned to either experimental or control groups while participants were not. As indicated earlier, previous studies used similar design. For example, Chikoko (1988) used twelve schools (twelve teachers) as an experimental group and the other twelve schools as a control group. Similarly, Mbano (2001) used four intact classes as an experimental group and the other four schools as a control group.

Subject teachers in the two experimental schools were trained in teaching of the learning skills and these taught their students for a period of fifteen weeks. Subject teachers in the control schools were trained in how to teach a difficult topic as a placebo treatment to mitigate *Harthone effects*.

3.3 Research strategy

This study used quantitative approach. All the questions required quantitative data to be answered. For example, question 1 used pretest and posttest scores and gender, which was coded whereby girls were given a code of '1' and boys were given a code of '0'. Question 2 used pretest and posttest scores; question 3 used pretest and posttest scores, age, and gender. Question 4 used frequency figures of responses from a Likert scale.

3.4 Administration of the intervention

The study was categorized into three parts. These are:

(1) Teaching of learning skills and difficult topics;

(2) Determining performance level of students in physical science; using the pre and post achievement tests; and

(3) The administration of a questionnaire, students learning strategy use.

Research questions 1, 3, and 4 formed the first part of this study while research question 2 made the second part of the study. The first part of the study addressed the problem of whether the teaching of learning skills improves performance level of students in physical science. To determine whether the intervention affects the achievement level of students, pre and post achievement physical science tests were administered to both the experimental and control groups. Scores generated from the tests were statistically analyzed. The dependence of the teaching of the learning skills on age and gender and possible interaction between the teaching of the learning skills and the learning strategies used by students were also ascertained. The second section sought to determine whether analyzing data using ANCOVA and independent sample t- test would produce similar results.

The following sections show how the research questions were answered. Table 3.1 shows an overall plan of answering the research questions in this study.

Table 3.1: Data collection planning matrix

Research aspect	**Aim**	**Type of data**	**Source**	**Time frame**
Performance in pre and post physical science tests	To show effects of teaching learning skills in the subject	Quantitative (scores)	Students responses to the tests	July to October, 2007
Relationship between results from ANCOVA and t-test on residualized gain scores	To show the differences in results if two different methods of data analysis are used	Quantitative (scores and age)	Students	July to October, 2007
Relationship between age or gender and performance	To show the interaction effects of age and gender on achievement.	Quantitative (scores and age) and Qualitative (gender)	Students	July to October, 2007
Learning strategy use	To establish the effects of teaching learning skills on learning strategy use.	Qualitative responses to the questionnaire	Students	November, 2007

Pretest and posttest were administered to both the experimental and the control schools to generate scores, which were statistically analyzed using 'ANCOVA' and 'residualized gain scores'. The results of the study obtained using the two different methods, ANCOVA and independent sample t-test on the residualized gain scores were compared to determine if there were differences in the results when the methods are used on the same data separately. It was also determined whether there was any association between the effects of teaching of learning skills and gender or age. Point biserial and Partial correlation coefficients were calculated and used. The study also explored the extent to which the teaching of the learning skills affects the choice of learning skills used when students are confronted with a learning task.

The effects of the extraneous factors and prior group differences, which could have contributed to the effects of the intervention on performance level of students, were reduced and partitioned out respectively using three methods: purposive sampling, analysis of covariance and residualized gain scores.

The first method was through purposive sampling of the schools involved in this study. The schools involved were all co-education government boarding, had laboratory facilities, and taught the same topics during the interventional period. The selection of similar schools reduced some preliminary group differences (Mbano, 2001; Creswell, 2002), which would have affected the variance in the performance level of the students. Schools involved in this study were at the time of study covering the same topics. Random processes were used in assigning a particular class to either experimental or control groups. The matching process when selecting the schools reduced differences in the factors such as materials used during instructional delivery and the cognitive demands of the concepts in the topics being covered.

The second method partitioned out effects of extraneous variables and preliminary group differences by using two statistical methods, analysis of covariance, ANCOVA (Hinkle, et al 1994) and independent sample t-test on the residualized gain scores (Borg & Gall, 1989).

3.5 Sample and sampling technique

3.5.1 Schools used in the study

The study used a multi-stage cluster sampling procedure when sampling the schools involved in the study. In multistage cluster sampling, the researcher chooses a sample in two or more stages because either the populations cannot be easily identified or they are extremely large (Creswell, 2002).

In this case, the population was too large and therefore, CEED was purposively selected on account of convenience. The researcher works in the CEED. Within the CEED, co-education secondary schools from five districts were selected. Homogenous sampling of schools was done in these five districts. To use this procedure, you need to identify the characteristics and find individuals or sites that possess it (Creswell, 2002).

Basing on the similarities of the schools (sites) in size, availability of laboratory equipment, type of school (proprietor), materials needed to cover the topics and school status (co-education schools), the schools were homogeneously selected.

Random numbers were used to select four secondary schools from a population of homogeneously sampled schools in the CEED secondary schools. Two schools out of the four were randomly assigned to either treatment or control groups after the administration of a pretest.

3.5.2 Students and sample size

After scoring the pretest and the posttest respectively, 110 students were randomly selected from each group; experimental and control groups, making 220 students. Their average age was 17.6 with a standard deviation of 2.5. The sample size was chosen in order to achieve the necessary statistical power and significance, for data analysis. When randomly selecting the candidates for analysis, 41 girls and 69 boys were selected from the experimental schools and the same proportions were selected from the control schools. There were inadequate numbers of girls in both groups to select equal numbers of girls and boys for each group. The experimental group had a limited number of girls (41) and as such, it served as a determinant of the number of girls from the control group to participate in this study.

The sample size was determined by using Lipsey sample size table from Creswell (2002). The level of significance was set at 0.05, the statistical power needed to reject the null hypothesis when it is false, was set at 0.95 and the effect size, which is the expected differences in the means between the control and the experimental groups was set at 0.5.

3.6 Data collection instruments

This section has been divided into three sub-sections; the pre and the posttests, students learning strategy questionnaire, and the learning skills program.

3.6.1 The pre and the posttest

The researcher developed the pre and the posttests (see appendix A and B). Formulation of the tests was guided by the principles of examination questions formulation, which are followed by MANEB. The principles are that each examination question has to be formulated basing on an objective of the syllabus (Rowell & Foster cited in Chikoko, 1988). In this study, sample questions were taken from MSCE 1998 to 2006 physical sciences past examination papers. The questions were modified to suit the purpose of the study. In this case, the questions were based on the objectives of physical science syllabus and past examinations.

3.6.2 Reliability of the tests

Reliability of the test scores was calculated using parallel forms reliability procedures. Parallel forms reliability, correlate scores from two alternate, parallel or equivalent forms of a test. The correlation between the two forms provided a reliability coefficient (Thorndike, 1997). The results showed that reliability of the tests was 0.56. Creswell (2002) says that; generally, reliability coefficients in the ranges of 0.6 are acceptable.

3.6.3 Validity of the tests

Content validity of the test was ensured by means of a careful and critical examination of the test items in relation to the course objectives and instruction. Borg and Gall (1989) advises that content validity is determined by systematically conducting a set of operations such as defining in precise terms the specific content universe to be sampled, specifying objectives, and describing how the content universe will be sampled to develop test items.

The aforementioned were considered; that the test content was what was in the curricular objectives, the content area where the items were formulated from was specified and agreed upon by the researcher and the subject teachers. All the students involved in the study were informed of the content area to be covered during the study. The level of difficulty was appropriate since the questions were modified from the past national examination questions and were based on the objectives of the syllabus. The questions addressed a representative sample of objectives in the topics under study in the syllabus. Students were aware about the textbooks and other reference materials to be used during the research period.

Borg and Gall (1989), say that the degree of content validity is not expressed in numerical terms as a correlation coefficient (validity coefficient) instead it is appraised by an objective comparison of the test items with curriculum content.

To ensure objectivity in the appraisal of validity of the test items, physical science teachers were used to comment on the items. The questions were accepted as having content validity. Table 3.2 shows some of the questions used in the pre and the posttest and syllabus objectives.

TABLE 3.2: Some items used in the pre and posttest, and their location in physical science syllabus

No.	Item	Location in the syllabus: Objective	Page
Q1a.	What is a Mole?	2 and 3	20
Q1b.	Define the term 'acceleration.'	6	24
Q2a.	Work out the empirical formula of a compound that has the following percentage composition by mass of elements: C= 40%; H = 6.67%; and O = 53.33%. (RAM: C = 12; H = 1; O = 16)	4	20
Q2b.	The following is a reaction between sodium hydroxide and hydrochloric acid; ($Na = 23; O = 16; H = 1; Cl = 35.5$) $NaOH(aq) + HCl(aq) \longrightarrow NaCl(aq) + H_2O(l)$ Calculate the mass of $NaOH(aq)$ which would react with 120g of $HCl(aq)$	9	22

Questions designated as (a) were in a pretest while those designated as (b) were in the posttest. The pretest was based on the following topics; '*Elements and Chemical bonding'* and part of '*Chemical reactions 1'*. The choice of the topics was determined at a briefing meeting I had with subject teachers of the schools involved in the study and was based on common topics already covered by all the participating schools.

The posttest was based on the following topics; *'chemical reaction 1'* and *'forces and motion'*. The choice of these topics was also agreed upon by the teachers and the researcher because the teachers had to finish teaching the topic of '*Chemical reactions 1'* which was not finished when students were writing their pretest and all the teachers agreed to continue with *'forces and motion'.*

Both tests contained five questions. Each test was marked out of 30 points.

The questions aimed at soliciting answers from the students addressing the non-mastered skills cited in the chief examiners' reports. Problems such as poor diagrams, lack of manipulative skills, difficulties in describing and designing experiments, and problems in defining scientific terms and illogical reasoning in explanations when answering examination questions have been attributed to the problem of poor performance in the subject. The questions examined '*ability to define a scientific concept'* (e.g., what is a Mole?), *'manipulative skills',* (e.g., Work out the empirical formula of a compound that has the following percentage composition by mass of elements: C= 40%; H = 6.67%; and O = 53.33%. (RAM: C = 12; H = 1; O = 16) and *'designing and describing experiments using well labeled diagrams',* (e.g., With the help of well-labeled diagram, describe an experiment that could be used to determine the concentration of a sulphuric acid using sodium hydroxide solution of a known concentration).

3.6.4 Pre-testing

The pretest was administered to physical science form 3 class students in both the experimental and control schools before the commencement of the implementation of the intervention program.

3.6.5 Post testing

After a period of 15 weeks of teaching the learning skills in experimental schools, a posttest was administered to both the control and experimental schools. Findings are presented and discussed in chapter 4 and 5 respectively.

3.7 The learning skills program

The learning skills were adapted from Learning Skills Program designed by the University of Victoria, Counseling Services (2007). The skills were in the categories of study/reading methods (SQ3R, SQ4R, PSQ5R and MURDER), using memory effectively (Mnemonics), learning diagrams, learning scientific definitions (designed by the researcher), tips for test taking, time management, preparing for essay style exams and learning with a study group, (see appendix C). Some parts of the learning skills program were designed by the researcher to make connections from one section of the learning skills to the other. For example, the researcher designed the introduction, learning scientific definitions and learning to describe experiments.

3.8 The questionnaire

Forty students responded to a self-report questionnaire, part of the motivated strategies for learning questionnaire (MSLQ) developed by Pintrich and De Groot (1990). The questionnaire included 23 items on self-regulation and cognitive strategy use. Students were asked to respond to the items on a 5-point Likert scale (1 = very true of me to 5 = not at all true of me). The questions were adapted to the situation in the CEED. Some of the questions were completely left out because they were not relevant to the aims of this study. Questions that addressed motivational issues were some of the questions, which were left out. Table3.3 shows some of the questions in the questionnaire.

Table 3.3: Examples of questions used to test for cognitive strategy and self-regulation.

(a) Cognitive strategy use questions;

1. When I study for a test, I try to put together the information from class and from the books.

2. When I do homework, I try to remember what the teacher said in class so I can answer the question correctly.

3. It is hard for me to decide what the main ideas are in what I read.

(b) Self-regulation questions;

15. I ask myself questions to make sure I know the material I have been studying.

16. When work is hard, I either give up or study only the easy parts.

17. I work on practice exercises and answer end of chapter questions even when I do not have to.

The items are categorized into two sections; cognitive strategy use, (1 to 14), and self-regulation (15 to 23), (see appendix J). The reported reliability of the cognitive strategy use and self-regulation were 0.83 and 0.74 respectively.

3. 9 Data analysis

Data were analyzed by using five methods. The statistical methods were; analysis of covariance (ANCOVA), independent sample t-test on the residualized gain scores**,** point biserial correlation, partial coefficient correlations and chi-square.

3.9.1 Analysis of covariance

The analysis of covariance was used to answer research question 1 about whether there were any statistically significant differences, in the performance of students who were taught learning skills and those who were not taught the skills in senior secondary physical science.

This study used intact groups whereby treatment was randomly assigned to the groups while the students were not. Therefore, this design called for the use of ANCOVA in order to adjustment for preexisting differences that may have existed among the experimental and the control groups prior to the research.

In this study, pretest scores were used as a covariate, posttest scores were taken as the dependent variable while group type and gender were the two independent variables (see appendix D). The pretest scores were used to statistically adjust the posttest scores for preexisting differences between the experimental and the control groups. Cohen and Manion (1989), Hinkle et al (1994) and Creswell (2002) support the use of ANCOVA and pretest mean scores as a covariate to control and adjust for preliminary group differences between the experimental and the control groups in experimental designs.

3.9.2 Independent sample t–test on the residualized gain scores

To answer research question 2 about whether there were any differences between the results obtained using ANCOVA and those obtained using independent sample t–test on the residualized gain scores, data were analyzed using independent sample t-test on the residualized gain scores (see appendix E). The results obtained from the analyses were compared on whether the statistical test was significant (through p-values) and on the effect size between the results obtained from the use of ANCOVA and the independent sample t-test.

3.9.3 Partial correlation coefficients

To answer the first part of research question 3, partial correlation coefficients, r, were used to analyze the relationship between achievement scores and age while controlling for their pretest scores. Pallant (2003) explains on the use of the coefficient that partial correlation is similar to Pearson product-moment correlation, except that it allows you to control for an additional variable.

In this study, pretest scores were taken as a covariate and as such, it was controlled so that its influence is removed. Partial coefficient correlation between the individual total scores in the posttest and age were computed while controlling for their pretest scores in order to answer the first part of research question 3, whether the teaching of learning skills are age dependent (see appendix F). It was hypothesized that there would be no differences between the two groups.

3.9.4 Point biserial correlations

Point biserial correlations were used to analyze the relationship between achievement scores and gender (see appendix G). This was used to answer the second part of research question 3. Hinkle et al (1994) say that point biserial correlations (r_{pb}) is the special case of the Pearson r in which one variable is a quantitative variable measured on an interval or ratio scale and the other is a nominal (dichotomous) variable.

In this study, achievement scores are measured on ratio scale while gender is measured on a nominal scale. Females were given a code of ‘1’ and males were given a code of ‘0’. Point biserials for a total score of each student obtained in the pre and posttests were computed to answer the second part of research question 3, to determine whether the effects of teaching of the learning skills are gender dependent. It was hypothesized that there would be no differences in the effects of teaching of the learning skills based on gender.

3.9.5 Chi square test

Responses on the structured questionnaire were analyzed using a chi-square, χ^2, test of homogeneity to answer research question 4. Hinkle et al (1994) comments that chi-square χ^2 test of homogeneity is frequently used to compare two or more groups on a nominal variable with two or more categories.

The chi-square test was used because both variables are qualitative in nature that is measured on a nominal scale. The test of homogeneity was used because one variable was random (use of learning skills) and the other variable (teaching the learning skills) was fixed (see appendix H and I). It was hypothesized that there would be no difference in the use of learning strategies between the students taught learning skills and those not taught the skills.

3.10 Ethical issues

The National Commission for the Protection of Human Subjects of Biomedical and Behavioral research (NCPHSBB Research)(1979) produced Belmont Report that guided ethical considerations of this study. The research and publications committee of the University of Malawi recommends consideration of the ethical issue basing on the report, (Dzama, 2007a, p. 190). The Report recommends that standards of ethical issues should be based on three principles; respect of persons, beneficence and justice.

3.10.1 Respect of persons

Respect of a person entails that an individual should be treated as autonomous agent and that persons with diminished autonomy are entitled to protection. The requirement to acknowledge autonomy was done by seeking permission to conduct the experimental research in the selected schools from the Education Division Manager, (CEED), the Head teachers of the concerned schools, the Heads of departments, subject teachers and the students themselves.

Permission to do the study was sought from the education division manager (EDM) who gave me the letter that allowed me to go to the participating schools to do the research. A copy of the letter is available at appendix N. This letter was not taken as an automatic go ahead to do the research. I briefed the head teachers of the involved schools in person about the study. I was accepted and directed to the heads of science departments in the respective schools. The heads of departments accepted me and informed the subject teachers.

The subject teachers were called for a meeting at a Teacher Development Centre (TDC). The subject teachers were requested to assist in the research by acting as research assistants and were trained for the task. Students were briefed about the study and were assured of confidentiality of any data obtained from them. Participation was made voluntary after the briefing sessions about the research. Confidentiality was ensured by the use of the identity numbers instead of their names for any documents submitted to the researcher. By briefing the concerned individuals and allowing them to give their views on the study and that participants entered into the study voluntarily with adequate information, respect for persons was taken care of.

3.10.2 Beneficence

The principle of beneficence entails securing the participants well being. There are two general rules, which have been formulated as complementary expressions of beneficent actions, do not harm and maximize possible benefits and minimize possible harms. Discovering that one cannot answer a given question is stressful and upsetting. The program included debriefing sessions whereby revision of the questions were done and students were assured that any score obtained in the pre and posttests would not contribute to any assessment reports in the school. Students were also briefed on the findings of the research.

3.10.3 Justice

This principle entails fair distribution of benefits and burdens. In this study, students benefited from the teaching of the learning skills. It is believed that, teaching of learning skills improved performance level in examinations. In the control schools, students were taught the same skills after collection of data. Students, subject teachers and the researcher were expected to work hard for the research to reduce errors in its conclusions. The aspect of working hard is a burden to the participants and needed to be shared.

3.11 Conclusions

This chapter has outlined the choices and reasons of research design, research strategy, and the methods of analysis used in this study. It has shown how other similar research studies collected and analyzed their data. This study has combined data analysis procedures used in the similar studies and compared with other effective recommended methods of analyzing the data. The results of the study are presented and discussed in chapter 4 and conclusions and recommendations are presented in chapter 5.

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CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This study set out to determine the effects of teaching learning skills, on achievement level of students, in senior secondary physical science. The study also determined whether there would be no differences between the results obtained using ANCOVA and those obtained from independent sample t–test on the residualized gain scores. In this chapter the results of analysis of the data collected through pretest, posttest, and the questionnaire are reported and discussed. A summary statement of the findings will be presented under each research question. The discussions of the results will be in relation to the findings of related studies of other authors found in the literature.

4.2 Results

4.2.1 Effects of teaching learning skills on students' achievement level in senior secondary physical science

The analysis of the data obtained through the pretest and the posttest using ANCOVA have shown that there were statistically significant differences in the performance between the two groups; experimental and the control groups.

The hypothesis that there would be no difference between the performances of the students taught the learning skills, and those not taught the skills was rejected at 0.05 level of significance. What follows are details of the results based on the data analysis using ANCOVA.

4.2.1.1 Using analysis of covariance

A 2 by 2 between groups analysis of covariance was conducted to assess the effects of teaching learning skills on students' achievement level in senior secondary physical science. In this study, the two independent variables were the type of group (experimental and control groups) and gender (male and female students). The dependent variable was the scores of the physical science posttest, which was administered after the implementation of the learning skills program. Pretest scores were used as a covariate to control for individual differences.

Preliminary checking of the assumptions of normality, linearity and homogeneity of regression of slopes were conducted to ensure that there were no violations of these assumptions. (See appendix K for the test of the assumptions of normality and appendix L for the assumption of linearity).

Table 4.1 shows the results of analysis of covariance for the posttest scores, adjusted for the covariate (pretest scores), to compare the performance of the students on the posttest between the control and the experimental groups.

TABLE 4.1: Summary of ANCOVA for the posttest scores in the presence of a covariate (pretest scores)

Source	**Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**	**Partial Eta Square d**
Covariate	1538.710	1	1538.710	51.943	.000	.195
Gender	375.333	1	375.333	12.670	.000	.056
Group	871.035	1	871.035	29.404	.000	.120
Gender * Group	226.784	1	226.784	7.656	.006	.034
Error	6368.901	215	29.623			
Total	44568.000	220				
Corrected Total	9084.200	219				

a. Computed using alpha = .05

After adjusting for the pretest scores, the main effects were statistically significant [type of group: F (1, 215) =29.404; $p\angle 0.0005$; gender: F (1,215) =12.670, $p\angle 0.0005$]. There was also a significant interaction effect, F (1,215) =7.656, p=0.006, with a small effect size (eta squared = 0.034). The effect size [ES] of the covariate (pretest scores) and type of group are large (partial eta squared = 0.195 and 0.120 respectively). This means that the pretest scores and the group type can explain 19.5 per cent and 12 per cent of variance in the posttest scores respectively. The ES of gender is moderate (partial eta squared = 0.056) while ES of the interaction effect between group type and gender is small (partial eta squared = 0.034). This means that gender differences and the interaction effect of type of group and gender can explain 5.6 per cent and 3.4 per cent of variance in the posttest scores respectively.

The results suggest that there were statistically significant differences in the performance between the two groups based on the posttest scores after partitioning out the effects of preliminary group differences. The analysis also shows that male and female students achieved differently in the two groups. The results further suggest that both belonging to a particular group and gender had statistically significant influence on the achievement scores in the posttest.

Posttest group means were computed to determine whether the intervention had a positive effect on the experimental group. Table 4.2 shows group means calculated to compare the group differences in their performance in the posttest.

Table 4.2: Group means for the performance in the posttest

Gender	**Type of group**	**Mean**	**Std. Deviation**	**Total number of students**
Male students	Experimental	15.93	5.34	69
	Control	12.23	7.07	69
Female students	Experimental	10.46	5.87	41
	Control	10.29	5.47	41
Total	Experimental	13.89	6.12	110
	Control	11.51	6.56	110

The posttest mean for the experimental group (13.89) is higher than the posttest mean of the control group (11.51). Since it has been shown that there were statistically significant differences in the performance of the two groups, then, it could be argued that the teaching of the learning skills improved the performance level of the experimental group in the subject. The estimated marginal means (see appendix M) of the posttest shows that girls consistently performed lower than their male counterparts in the experimental and control groups.

The results of this study lend support to the studies, which reported that teaching of learning skills to students improve students' performance, (Cao & Neitfeld, 2007; Michalsky & Mevarech, 2005; Ronzencwajg, 2003 and Mbano, 2001). The findings also support the suggestion by Grayson (1996, 1997) that one possible solution to the problem of poor performance could be the presentation of both the content and the learning skills. In the same context, Dzama (2007a) contended that students' limited knowledge of learning skills is one of the factors that have to be addressed to improve learning in science. He says that for learners to become strategic in their studies, they need to have a repertoire of learning skills. The contention implies that the absence of knowledge of these skills leaves the learners using limited learning skills for all the learning tasks. The teaching of the learning skills provided them with a wider choice of learning skills to be used to tackle different types of tasks thereby improving in their achievement levels in the subject.

In their review of research on metacognitive knowledge, Presseley et al (1998) contend that some forms of metacognitive knowledge necessary for planning can be imparted through direct training and planned activities. The teaching of the learning skills has demonstrated the observation that some metacognitive knowledge skills can indeed be trained through planned activities. In the same context, Flavell cited in Derry and Murphy (1986) said that there are four trainable cognitive categories, which schools might attempt to teach. These are; learning tactics (action), recognizing what they must learn (goals), enhancing the frequency and quality of experiences that lead to insights about learning (meta-cognitive experience) and building a store of information about the utility of learning tactics, which includes when and how to use them (meta-cognitive knowledge). The teaching of learning skills provided students with meta-cognitive knowledge, which governs how and when to use the leaning tactic. The study has also confirmed the finding that these different cognitive strategies such as rehearsal, elaboration, and organizational strategies foster active cognitive engagement in learning and result in higher levels of achievement (Weinstein & Mayer, 1988).

4.2.2 Comparison of the results of ANCOVA and independent sample t- test on the residualized gain scores

Analysis of data using both ANCOVA and the independent sample t-test on the residualized gain scores shows that there were significant differences in the performance level between the two groups; experimental and control groups.

The hypothesized that there would be no differences between the results obtained using ANCOVA and those obtained using independent sample t–test on the residualized gain scores. The difference in the results was investigated by comparing whether the statistical test was significant (through p-values) and on the effect size, between the results obtained from the use of ANCOVA and the independent sample t-test. What follows is the analysis of the data using independent sample t-test on the residualized gain scores.

4.2.2.1 Using independent sample t-test on residualized gain scores

An independent sample t-test on the residualized gain scores was conducted to compare the residualized gain scores on physical science achievement tests for the experimental and the control groups (see appendices D and F). Table 4.3 shows the significance of the differences in the gains the two groups made after the implementation of the intervention program.

TABLE 4.3: Independent sample t-test on the residualized gain scores of the experimental and the control groups

Scores	**Levene's test for equality of variances**		**t-test for equality of means**		
	F	**Sig.**	**T**	**Df**	**Sig. (2-tailed)**
Equal variances assumed	72.377	.000	6.427	218	.000
Equal variances not assumed			6.427	131.41	.000

Levene's test for equality of variances shows that the assumption of equal variances is rejected. Since the assumption of equal variance is not satisfied, (F=72.377; $p\angle 0.0005$), an assumption of equal variance was not assumed. The results show that there were statistically significant differences in the extent of gain during the intervention period [t (131.41) =6.427; $p\angle 0.0005$]. Table 4.4 shows residualized group means to determine which group gained more after the implementation of the intervention.

Table 4.4: Group means for residualized gain scores

Group	Total number of students	Gain score group mean	Std. Deviation
Experimental	110	6.41	1.84
Control	110	2.74	5.70

The results show that there was a significant difference in the residualized gain score means between the two groups, [experimental group: M = 6.41; SD = 1.84; t (131.42) = 6.427; $p\angle 0.0005$; control group: M = 2.74; SD = 5.70; t (131.42) = 6.427; $p\angle 0.0005$]. The magnitude of the effect size (eta = 0.184) was large (Pallant, 2003 p. 181). This effect size means that the type of group the students belong to explains 18.4 per cent of the variance in the residualized gain scores.

Since the residualized gain score mean for the experimental group (6.41) is higher than the residualized gain score mean for the control group (2.74), then, it implies that the teaching of the learning skills improved performance level of the experimental group in the subject.

The use of ANCOVA, [type of group: $F\ (1, 215) = 29.404$; $p \angle 0.0005$; gender: $F\ (1,215) = 12.670$, $p \angle 0.0005$] and independent sample t-test, [experimental group: M = 6.41; SD = 1.84; $t\ (131.42) = 6.427$; $p \angle 0.0005$; control group: M = 2.74; SD = 5.70; $t\ (131.42) = 6.427$; $p \angle 0.0005$] shows that there are significant differences between the experimental and the control groups.

The group effect size (ES) obtained from the use of ANCOVA is lower (0.120) than that obtained from the use of independent sample t-test (0.184). Cohen (1989) defines effect size as the 'degree to which a phenomenon exists'. It is a means for identifying the strength of the conclusions about group differences or about the relationship among variables in a quantitative study. Hand (1994) observes that t-test and ANCOVA ask about different issues. The first (t-test) ask whether the average gain in score is different for the two groups while ANCOVA ask whether the average gain, partialling out pre-scores, is different between the two groups. The partialling out of the effects of the pre-scores reduces the effect size but increases the precision of the results in ANCOVA.

Comparison of the achievement gains in the experimental and control groups used differences between the posttest and pretest scores in the two groups. The posttest and the pretest scores are the observed scores, which comprise of true and error scores. As mentioned earlier, true scores are constants while error scores are a result of effects of a disturbance that is due to a composite of a multitude of factors that are not controlled in the measurement procedure.

Methods of data analysis in a study are employed considering the type of data collected, the study design, sampling procedures followed in the study and the theoretical assumptions of the statistical method used. Most of the quasi-experimental studies in real education setting use non-randomized subjects when assigning them to either experimental or control groups though it is possible to randomly assign treatments to the experimental and control groups. In this scenario, there are a number of variables, which could negatively affect the results. Therefore, a researcher is supposed to control these extraneous variables starting from design stage to data analysis.

In this study, some extraneous variables were controlled at the design stage through matching in order to reduce their effects on the dependent variable (posttest observed scores). This process reduced their contribution to the error score increase. These variables were such as teaching and learning materials, teaching methods (guided discovery) and type of school.

ANCOVA was used because it increases the statistical power of the test and controls the effects of extraneous variables.

During the implementation of the intervention, other extraneous variables influence the effects of the intervention on the dependent variable. If the effects of such variables are not reduced or partitioned out, the results may be confounded by these extraneous variables. Although independent sample t-test takes into account the starting levels of test-takers by using pretest scores to predict posttest scores through use of a regression equation, the method does not partition out the effects of extraneous variables, which affect the scores during the intervention period. This could explain why the effect size from independent sample t-test on the residualized gain scores is higher than that from ANCOVA. This finding implies that independent sample t-test on the residualized gain scores should be used bearing in mind that the effects of some extraneous variables, which affect the dependent variable during the implementation of the intervention, are not partitioned out thereby contaminating the results of the study.

Another pertinent drawback of using independent sample t-test on the residualized gain scores is the theoretical assumptions of the test. A t-test is a special type of analysis of variance and its major assumption is that subjects are assigned randomly to either experimental or control groups. If intact groups are used in an experiment, then use of independent sample t-test when comparing sample means would be wrongly employed.

The results of this study that both methods yield similar results could therefore not be taken as a justification of using both methods interchangeably in such studies. Wright (2006) advises that if the allocation of participants is based on the initial score, the ANCOVA approach produce unbiased estimates for the effectiveness of the treatment. He however, says that if the allocation is only associated with the initial scores, the choice of the statistical method is more complex. There is a need to consider a number of issues before choosing method of data analysis in quasi-experimental studies. Maxwell and Delaney (2004) say that an ANCOVA is usually the preferred approach, but that there are situations where t-test analysis of the differences is the preferred approach.

4.2.3 Effects of age and gender on the teaching of learning skills

4.2.3.1 Age and performance

Generally, students of lower age were found to be associated with higher performance in the posttest than their older counterparts.

The relationship between age and the effects of teaching learning skills on students' achievement level in senior secondary physical science posttest scores was investigated using partial correlation coefficients. Table 4.6 shows partial correlation coefficients for determining whether there is a relationship between age and the effects of teaching the learning skills on students' achievement levels in the subject.

Table 4.5: Partial correlation coefficients between age and achievement scores in the posttest controlling for pre-test scores

Group	Male	Female
Experimental	R = -0.135 (p =0.271)	r = +0.130 (p = 0.424)
Control	R = -0.116 (p = 0.344)	r = -0.044 (p = 0.786)

With the exception of the performance of the female students in the experimental group, there were weak, negative relationships between age and achievement of the students in the subject. The negative partial correlations show that generally lower age is associated with higher achievement in the posttest. In this case, students with lower age tended to score high than their counterparts.

The positive partial correlation between posttest scores and the age of female students in the experimental group may mean that older female students may have gained more from the teaching of the learning skills than their male counterparts in the same group.

The observations in this study concur with those of other studies (Mbano, 2001; Dzama & Osborne, 1999; Dzama, 1984). For example, Dzama (1984) found that there were a pronounced negative correlation between age of the students and their scores on the cognitive development and between age and attainment. This meant that younger students were more likely to perform well in physical science than the older students were. The finding of this current study agrees with those of Dzama (1984) that younger students are associated with higher achievement in physical science.

In the same context, Mbano (2003) observed that in Malawi, girls, who are one year younger than boys in the same class and older boys, had lower academic achievement than younger boys. Furthermore, Dzama and Osborne (1999) in their study of poor performance in sciences among African students: an alternative explanation to the African worldview thesis, investigated causes of poor performance among students in Africa. A factor analysis showed that there were three factors, which account for the variance in their performance. These were their scientific ability, age and traditional beliefs. They also obtained negative correlations between age and performance in reasoning tasks (-0.29) and between age and electricity test (-0.12). The negative correlations show that younger students were associated with higher scores.

4.2.3.2 Gender and performance

The results show that female students tended to score lower than their male counterparts in both the experimental and the control groups and in the two tests.

The relationship between gender and the achievement level in the subject was investigated using point biserial correlation coefficients between gender and the students' achievement scores in the posttest. Table 4.6 shows the results of point biserial correlations between pretest/posttest scores and gender for determining whether there is gender interaction in the effects of teaching learning skills on students' achievement level in physical science.

TABLE 4.6: Point biserial correlation coefficients of scores of the pretest, posttest and gender

	Pretest	Posttest
Experimental group	$r_{pb} = -0.109$	$r_{pb} = -0.315$
Control group	$r_{pb} = -0.163$	$r_{pb} = -0.171$

Point biserial correlation coefficients, r_{pb} for all the categories are low and negative. They show little, if any, correlation between gender and performance except for the experimental group in the posttest. Since girls were assigned a code of '1' while boys were assigned a code of '0' then, the correlations would mean that girls tended to score lower than boys in both the experimental and control groups and in both the pre and post achievement tests. Comparatively, the relationship between gender and achievement is stronger in the experimental group for the posttest, ($r_{pb} = -0.315$). The coefficients of determination for the experimental and the control groups show that 9.9% and 2.9% of the variance in the scores could be explained by gender differences respectively. This may mean that the effects of teaching learning skills are gender dependent. Since there is a stronger relationship in the experimental group, one may be compelled to conclude that the effects of teaching of the learning skills favored more male students than their female counterparts.

The findings of the current study support findings in the literature that girls tend to score lower in physical science than boys. Mbano (2001) in a study of the effects of CASE intervention program on the performance of secondary school pupils in Malawi found that girls, who are on average a year younger than boys in the same class, and older boys, had lower academic achievement than younger boys. Parker, Rennie and Harding, (1995) suggests some factors that account for the poor performance of girls in sciences as; girls' prior experiences, the image of science and the nature of 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 the same context, Kamwendo (1984) investigated factors that adversely affect the performance of Malawian girls as compared to that of boys. He found that among many factors that contribute to the poor performance of girls are; negative attitude towards physical science, no job relevancy, lack of class participation, gender bias textbooks, participation in scientific activities and subject difficulty. The factors mentioned by Kamwendo's (1984) study may still be responsible for the poor performance of the girls.

The results of the current study also support Mbanos' (2001) findings that the effects of an intervention program have gender interaction effects on academic achievement in Malawi. Similar findings have also been found in a number of studies. Preece, Skinner and Riall, (1999) explored gender differences in science achievement in England and Wales at the end of 9th year of schooling. Gender differences were more pronounced in high performing students. Preece et al (1999) found that questions that are more discriminating show gender differences in favor of males.

On the contrary, gender differences favoring boys are nonexistent in lower primary classes but become significant in secondary schools. It has also been observed that the differences tend to be highest among best performing students (Preece et al, 1999). Kerr and Kurpius (2004) observed that the differences of boys and girls have been declining with time. Francis (2000) and Demie (2001) have found that girls are now performing better than boys.

Although gender differences still exist in Malawi, the low correlations may suggest that the differences between boys and girls are declining as Kerr and Kurpius (2004) suggest.

4.2.4 Effects of the teaching of learning on learning strategies used by the students in learning senior secondary physical science

There were statistically significant differences in the two groups in their responses on the use of self-regulated and meta-cognitive learning strategies when learning physical science.

A structured questionnaire was used to solicit the use of self-regulated learning strategies, and meta-cognition during learning. Data from the structured questionnaire was analyzed using a chi-square, χ^2 test of homogeneity.

4.2.4.1 Self-regulated learning skills use

Table 4.7 shows chi-square statistic and the critical value of the chi-square used to compare the frequency of responses on the uses of self-regulatory learning skills between the experimental and the control groups.

TABLE 4.7: Computed chi-square statistic (χ^2) and the critical value of the chi-square (χ^2_{cv}) for self-regulated strategy use.

χ^2	χ^2_{cv}
6.502	5.991

The chi square statistic $\chi^2\,(2, \mathrm{N} = 20)$ = 6.502 exceeds the critical value ($\chi^2_{cv} = 5.991$), $\mathrm{P}\angle .05$ (The observed frequencies can be found in appendix I). This means that there is a difference in the two groups in their self-regulation when learning senior secondary physical science. Table 4.8 shows the standardized residuals used to indicate which group tended to agree to have been using the self-regulated learning skills.

Table 4.8: Standardized residuals for the frequencies of responses on the use of self-regulated learning skills

	Use of self-regulated learning skills		
Teaching of learning skills	True of me	Not sure	Not true of me
Learning skills taught	0.9	-1.6	-0.05
Learning skills **not** taught	-0.9	1.6	0.05

The standardized residuals show that more students in the experimental group tended to agree to have been using self-regulated learning strategies while more students in the control group tended to indicate that they do not use self-regulated learning strategies.

4.2.4.2 Meta-cognitive learning skills use

Table 4.9 shows chi-square statistic and the critical value of the chi-square used to compare the frequency of responses on the uses of meta-cognitive learning skills between the experimental and the control groups.

TABLE 4.9: Computed chi-square statistic (χ^2) and the critical value of the chi-square (χ^2_{cv}) for meta-cognitive strategy use.

χ^2	χ^2_{cv}
6.166	5.991

The chi square statistic ($\chi^2 = 6.166$) exceeds the critical value ($\chi^2_{cv} = 5.991$), (The observed frequencies can be found in appendix H). This means that there is a difference in the two groups in their use of meta-cognitive learning skills. Table 4.10 shows the standardized residuals used to indicate which group tended to agree to have been using the meta-cognitive learning skills.

Table 4.10: Standardized residuals for the frequencies of responses on the use of meta-cognitive skills

	Use of meta-cognitive learning skills		
Teaching of learning skills	True of me	Not sure	Not true of me
Learning skills taught	1.32	0.52	-1.01
Learning skills **not** taught	-1.34	-0.53	1.03

The standardized residuals show that more students in the experimental group tended to agree to have been using meta-cognitive learning strategies while more students in the control group tended to indicate that they do not use the meta-cognitive learning strategies when learning the subject.

The observations made in this study support the finding of Cao and Nietfeld (2007) that students' awareness of different kinds of difficulties in learning the class content does not lead to adjustment of learning skills. Students reported not using effective learning skills. They primarily relied upon passive use of rehearsal strategies rather than strategies that are supported by literature as being more effective such as elaboration and outlining chapters. It may be recalled that students in the experimental group performed better compared to those in the control group. The students in the experimental group tended to agree to have been using self-regulated and meta-cognitive learning skills. This finding support the assertion that higher achieving students us more self-regulated learning strategies than do the lower achieving students, (Shraw & Dennison cited in Cao and Nietfeld, 2007; Zimmerman & Merntinez-Pons, 1988). In this current study, higher achieving students are those in the experimental group. These tended to agree to have been using the self-regulated and meta-cognitive learning skills while the low achieving students (the control group) tended to disagree to have been using the skills.

4.3 Conclusion

The teaching of learning skills in the senior secondary school physical science has been shown to improve performance level of students in the subject. The use of different methods of data analysis yielded similar results with different details of insights of the effects of the intervention. The effects of the intervention are age and gender dependent. The results show that the teaching of learning skills enhances the use of effective self-regulated and meta-cognitive learning skills when learning senior secondary school physical science. The following chapter discusses these results.

CHAPER 5

CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS

5.1 Introduction

This study endeavored to determine and document; the effects of teaching learning skills on students' achievement level in senior secondary physical science and the type of results obtained by analyzing data using different methods. The previous chapter has presented and discussed the findings of the study in relation to the observations in the related literature. This chapter will present principal conclusions and the implications of the results of the study. Recommendations for practice and further research will also be presented in the chapter. The significance, limitations and the general conclusion will be summarized at the end of the chapter.

5.2 Summary of results

5.2.1 Research question 1: How would teaching students learning skills affect their performance in senior secondary physical science?

There were statistically significant differences in the performance between the two groups; the experimental and the control groups, based on the posttest scores after partitioning out the effects of the preliminary group differences. It was also observed that male and female students gained differently in the two groups from the learning skills program.

5.2.2 Research question 2: Would the use of ANCOVA or an independent sample t-test during data analysis produce different results?

The two analytical methods; ANCOVA and an independent sample t- test on the residualized gain scores, yielded similar results with different details of insights on the effects of the intervention.

5.2.3 Research question 3: Are the effects of teaching learning skills age and gender dependent?

Lower age has been found to be associated with higher achievement in the posttest. In this case, younger students tended to perform better than the older students did. It has also been observed that older female students seem to have gained more from the teaching of the learning skills than the male and younger female students have.

It has been found that girls tended to score lower than boys in both the experimental and the control groups. The relationship between gender and achievement has been observed to be statistically low.

5.2.4 Research question 4: How would the teaching of the learning skills affect learning strategies used by the students in learning senior secondary physical science?

There were differences in the two groups in their use of self-regulatory and meta-cognitive learning skills. More students in the experimental group tended to agree to have been using the self-regulatory and meta-cognitive learning skills than the students in the control group did.

5.3 Principal conclusions and the implications of the results of the study

5.3.1 Effects of teaching learning skills on students' achievement level in senior secondary physical science

The results of the study show that the teaching of learning skills to students improves performance level of the students in senior secondary physical science. It is further observed that the effects of the intervention of learning skills are gender biased.

The effects of the intervention in the subject were investigated through an experimental design. Two schools, using form three physical science classes, were assigned as a single experimental group while the other two schools using a similar form was designated as a control group. Their subject teachers taught students in the experimental group learning skills while the students in the control group were not taught the skills except that their subject teachers were oriented on how to teach difficult topics in the subject.

Determination of differences in the achievement level of students in the two groups was done through data analysis from the pre and post achievement physical science tests. Data, in a form of scores, were analyzed using two statistical methods; ANCOVA and residualized gain scores.

The implications of these results are that in order to improve the performance level of the students in senior secondary physical science, students should be taught learning skills. Flavell cited in Derry and Murphy (1986), suggest that students need not only be taught the subject content, they also need to be taught the learning skills and how and when to use the learning skills.

The observations that the effects of teaching of learning skills are gender biased, implies that in order to achieve the best from the intervention, there is a need to be making use of heterogeneous groups rather than homogeneous groups in learning activities.

5.3.2 Comparison of results of the study obtained using ANCOVA and independent sample t-test on the residualized gain scores.

The results show that both the use of ANCOVA and the independent sample t-test yield similar results. Independent sample t-test showed a high effect size than ANCOVA. However, the use of ANCOVA is more precise about the differences between the two groups, which included the effects of gender on achievement, than the use of independent sample t-test on the residualized gain scores. The two methods were compared on whether the statistical tests were significant (through p-values) and on the effect size, between the results obtained from the use of ANCOVA and the independent sample t-test.

The use of ANCOVA has two advantages over the use of independent sample t-test on the residualized gain scores when analyzing data from pre and posttest scores in quasi-experimental designs. Quasi-experimental designs usually use intact groups and are used to explain the effects of an independent variable on a dependent variable. The participants are not randomly assigned to either the treatment or control groups. ANCOVA is used in this case as a statistical method of controlling for the effects of extraneous variables, which may confound the results.

The first advantages of using ANCOVA is that it controls for the effects of extraneous variables by partitioning out variation attributed to these additional variables thereby increasing the precision of the results by reducing error variance. It is also used to increase the power of the statistical test. However, both methods, as already stated, yield similar results. The choice of the analysis method should depend on the type of research question as Hands (1994) advises that the two analytical methods answer different questions. It is important to understand which question is being answered.

5.3.3 The relationship between age or gender and achievement levels of students in senior secondary physical science

5.3.3.1 Age and achievement

The results lead to a conclusion that younger students perform better than the older students do.

The relationship was investigated by computing partial correlation coefficients between age and achievement scores in the posttest controlling for their pretest scores. The implications of this finding are that the choice of a mode of teaching should consider the fact that learning skills affect students' achievement levels and that achievement is related to age. In order to improve the achievement level of all the students of all age ranges, efforts must be made to form study circle groups comprising of students of varied age ranges. Another implication is what the literature points out that there might be a difference in how male and female students respond to different interventions. Pallant (2003) recommends that:

> In your own research always, consider factors such as gender and age, as these can play an important part in influencing the results (Pallant, 2003 p. 247)

The excerpt implies that in experimental and intervention research studies, there is need to include gender and age of the students as moderator valuables. These variables influence the effects of the other independent variable on the dependent variable. Moderator variables are individual characteristics, which influence the way individuals respond to experimental treatments.

5.3.3:2 Gender and achievement

The mean performance of girls was not significantly different from the mean performance of boys in the posttest. These observations call for a careful planning when fostering students learning. As already alluded to this implies that the study circle groups, learning arranges in classrooms and laboratories need to consider combining boys and girls of varied age ranges in the same group. This would influence optimal participation in learning activities for both girls and boys of all age ranges. The characteristics of boys and younger students that positively influences achievement level would be shared and improve the performance of all the groups of students.

5.3.4: The influence of teaching the learning skills on the learning strategies used by students when learning senior secondary physical science

The teaching of learning skills influences the use of effective learning skills among students when learning physical science.

The influence of teaching the learning skills on the choice and use of learning skills by students when learning physical science was explored using a questionnaire. Students in the experimental group tended to agree to have been using the self-regulatory and meta-cognitive learning skills. This means that in order for students to perform well, they need to use a number of learning skills.

As Dzama (2007a) maintains, that student's limited knowledge and use of learning skills could be one of the reasons that makes them perform poorly in the subject. This implies that in order to improve performance, students should be taught learning skills.

5.4 Recommendations for improving learning of senior secondary physical science

In view of the continued problem of poor performance in physical science and the learning strategies used by many students when learning physical science, I recommend that students should be taught both content and the learning tactics for a given task in a topic.

The performance of younger students has been shown to be better than that of their older counterparts. I recommend that formulation of study circle groups should always consider combining students of all age ranges so that the characteristics of the younger students, which respond favorably to the learning skills, be shared among the group members.

The differences in the performance level between girls and boys are a concern of those who endeavor to improve performance level of all the students. I recommend that girls should be given more chance of actively participating in the group discussions, laboratory work and answering class questions when learning the subject. The study circle groups should be a mixture of girls and boys of varied age ranges. A deliberate effort should be made by teachers to give girls active positions in their groups and during learning activities to encourage their participation.

I recommend that school practices that would encourage self-regulatory learning strategy use should be enforced. There are systems in schools, which would influence the use of effective learning skills. These are; study circle groups, use of personal study timetables, peer teaching, assignments, library periods, one to one teacher- student help and so many others. If schools deliberately encourage and enforce these systems, students would not depend on limited methods of learning skills and this would encourage self-regulation in learning and improve their academic outcomes.

5.5 Recommendations for data analysis in quasi-experimental designs to assess improvement in performance

Although the use of ANCOVA and an independent sample t-test produced similar results, I recommend that data analysis in quasi-experimental studies should consider the type of questions being answered before deciding on the method of analyzing data in such studies.

5.6 Recommendations for further research

Future research aimed at improving performance level of students in senior secondary physical science should focus on the learning side of the teaching-learning equation. When analyzing data from such studies, multivariate analysis of covariance (MANCOVA) should be used in order to include a number of independent variables and covariates. It would be a worthwhile study, to replicate the study of the effects of teaching learning skills on students' achievement level in physical science. The study would use the same design and use MANCOVA as an analysis method while incorporating more schools and sample size, increasing interventional period and using more covariates in order to realize generalizable results.

Literature points to the fact that the problem of poor performance in sciences in general and physical science in particular is contributed by varied factors. A study is required to find out which factors are major contributors to the problem of poor performance in the subject. This would assist in finding the best ways of tackling the problem of poor performance and the best learning strategies that would mitigate its effects on the performance level of students in the subject. Such a study could use an experimental design whereby different factors would be controlled in different schools and compare the performance levels of the students in different schools in the subject. The study would consider leveling out other pertinent factors such as use of the same teaching method in all the schools, which would be involved in the study.

Although the teaching of learning skills has shown that it improves the performance level of students, boys have been found to perform better than girls in both groups and tests. However, there was a positive relationship between age and achievement for the girls in the experimental group in their performance in the posttest. This may imply that older girls gained more from the teaching of learning skills than their counterpart younger girls, younger boys and older boys. More research is needed to understand which age range and gender benefits more from the teaching of learning skills.

A strong social desirability bias among secondary school students in Malawi was shown in the responses to the relevance of science education (ROSE) questionnaire, (Sjoberg and Schreiner, 2005). In the same context, Case (2004) argues that the presence of desirability bias among students weakens the use of questionnaires in determination of students' conceptions and approach to learning. In view of these observations, there is a need to conduct more research to understand what students think about the use of learning skills presented to them in science lessons and the learning skills they actually use in learning physical science.

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APPENDIX A

SENIOR SECONDARY PHYSICAL SCIENCE, PRETEST INSTRUMENT

SCHOOL NUMBER: CANDIDATE ID___________

SEX______________________

INSTRUCTIONS:

Answer all the questions.

Q1. What is a Mole?

Q2. Work out the empirical formula of a compound that has the following percentage composition by mass of elements: C= 40%; H = 6.67%; and O = 53.33%. (RAM: C = 12; H = 1; O = 16).

Q3. Explain why sodium chloride, $NaCl$ has a much higher melting point than $C_{70}H_{142}$.

Q4. Using suitable examples and with the help of diagrams in each case, explain the difference between the terms given below:

a. Hydronium and hydroxyl ions

b. Covalent bonding and ionic bonding

Q5. With the help of a well-labeled diagram, describe an experiment that could be used to identify solutions of polar or non-polar covalently bonded compound

END OF QUESTION PAPER

APPENDIX B

SENIOR SECONDARY PHYSICAL SCIENCE, POSTTEST INSTRUMENT

SCHOOL NUMBER: CANDIDATE ID__________

SEX_____________________

INSTRUCTIONS:

Answer all the questions.

Q1. Define the term 'acceleration.'

Q2. The following is a reaction between sodium hydroxide and hydrochloric acid;

$$NaOH(aq) + HCl(aq) \longrightarrow NaCl(aq) + H_2O(l)$$

Calculate the mass of $HCl(aq)$, which would react with 120g of $NaOH(aq)$.

($Na = 23; O = 16; H = 1; Cl = 35.5$)

Q3. Explain why bond making is endothermic and bond breaking is exothermic.

Q4a. Using suitable examples and with the help of energy profile diagrams explain the difference between endothermic and exothermic reactions.

Q4b. Explain the difference between scalar and vector quantities.

Q5. With the help of well-labeled diagram, describe an experiment that could be used to determine the concentration a sulphuric acid using sodium hydroxide solution of a known concentration.

END OF QUESTION PAPER

APPENDIX C

THE LEARNING SKILLS PROGRAM

INTRODUCTION TO LEARNING SKILLS

- Be familiar with the subject syllabus.
- Know the objectives of every topic before you start learning the concepts of the topic.
- Each objective has what has to be learnt under the content column – know all the concepts listed under content.
- A syllabus can assist you to study the subject by turning the objective into question form and aim at answering the questions as you are studying the topic. (see how to learn from textbooks)
- It is important to look at what has been suggested as teaching and learning activities. This would give you a clue as to what you are expected to do when learning the concepts of the topic.

A.STUDY /READING METHODS

1. The SQ3R Reading Method

SQ3R stands for:
Survey! **Q**uestion! **R**ead! **R**ecite! **R**eview!

STEP 1

Before you read, survey the chapter by reading;

- the title, headings, and subheadings.
- captions under pictures, charts, graphs or maps
- review questions or teacher-made study guides
- introductory and concluding paragraphs

- summary

STEP 2

Question while you are surveying:

- Turn the title, headings, and/or subheadings into questions;
- Read questions at the end of the chapters or after each subheading;
- Ask yourself, "What did my teacher say about this chapter or subject when it was being taught?"
- Ask yourself, "What do I already know about this subject?"

Note: If it is helpful to you, write out these questions for consideration. This variation is called SQW3R – Survey, Question, Write, Read, Recite, and Review

STEP 3

When you begin to Read:

- Look for answers to the questions you first raised;
- Answer questions at the beginning or end of chapters or study guides
- Reread captions under pictures, graphs, etc.
- Note all the underlined, italicized, bold printed words or phrases
- Study graphic aids
- Reduce your speed for difficult passages
- Stop and reread parts which are not clear
- Read only a section at a time and recite after each section

STEP 4

Recite after you have read a section:

- Orally ask yourself questions about what you have just read
- or summarize, in your own words, what you read
- Take notes from the text but write the information in your own words
- Underline or highlight important points you've just read
- Use the method of recitation which best suits your particular learning style but remember, the more senses you use the more likely you are to remember what you read - i.e.,
- TRIPLE STRENGTH LEARNING: **Seeing, saying, hearing-**
- QUADRUPLE STRENGTH LEARNING: Seeing, saying, hearing, writing!

STEP 5

Review: an ongoing process

Day One

- After you have read and recited the entire chapter, write questions in the margins for those points you have highlighted or underlined.
- If you took notes while reciting, write questions for the notes you have taken in the left-hand margins of your notebook.

Day Two

- Read the text and/or your notebook to re-acquaint yourself with the important points.
- Cover the right hand column of your text/note-book and orally ask yourself the questions in the left-hand margins.
- Orally recite or write the answers from memory.
- Make "flash cards" for those questions, which give you difficulty.
- Develop **mnemonic devices** for material, which need to be memorized.

Days Three, Four and Five.

- Alternate between your flash cards and notes and test yourself (orally or in writing) on the questions you formulated.

- Make additional flash cards if necessary.

READING TO COMPREHEND AND LEARN

Reading a Paper or Chapter

PSQ5R is a formula that stands for the basic steps in learning from reading in an efficient manner. The P stands for **Purpose**, the S for **Survey**, the Q for **Question**, and the 5 Rs for **Read Selectively, Recite, Reduce-record, Reflect**, and **Review**.

1. Purpose

Why are you reading this article or chapter, and what do you want to get out of it? When you have accomplished your purpose, stop reading. This principle, of first establishing your purpose, whether to get the Focus or Theme, or main ideas, or main facts or figures, or evidence, arguments and examples, or relations, or methods, can prompt you to use a reading method that gets what you want in the minimum time.

2. Survey-Skim

Glance over the main features of the piece, that is, the title, the headings, the lead, and summary paragraphs, to get an overview of the piece, to find out what ideas, problems, and questions are being discussed. In doing this you should find the *Focus* of the piece, that is, the central theme or subject, what it is all about; and perhaps the *Perspective*, that is, the approach or manner in which the author treats the theme. This survey should be carried out in no more than a minute or two.

3. Question

Compose questions that you aim to answer:

1. What do I already know about this topic? - in other words, activate prior knowledge.

2. Turn the first heading into a question, to which you will be seeking the answer when you read. For example; "What does the kinetic theory of solids/liquids/gases say?

4. Read Selectively

Read to find the answers to your question. By reading the first sentence of each paragraph you may as well get the answers. Sometimes the text will "list" the answers by saying

"The first point.... Secondly...." and so on. And in some cases you may have to read each paragraph carefully just to understand the next one, and to find the Focus or main idea buried in it. In general, look for the ideas, information, evidence, etc., that will meet your purpose.

5. Recite

Without looking at the book, recite the answers to the question, using your own words as much as possible. If you cannot do it reasonably well, look over that section again.

6. Reduce-Record

Make a brief outline of the question and your answers. The answers should be in key words or phrases, not long sentences. For example, "what are exothermic reactions? – give out heat energy. What are endothermic reactions? – absorbs heat energy.

7. Reflect

Recent work in cognitive psychology indicates that comprehension and retention are increased when you "elaborate" new information. This is to reflect on it, to turn it this way and that, to compare and make categories, to relate one part with another, to connect it with your other knowledge and personal experience, and in general to organize and reorganize it. This may be done in your mind's eye, and sometimes on paper. Sometimes you will at this point elaborate the outline of step 6, and perhaps reorganize it into a standard outline, a hierarchy, a table, a flow diagram, a map, or even a "doodle." Then you go through the same process, steps 3 to 7, with the next section, and so on.

8. Review

Survey your "reduced" notes of the paper or chapter to see them as a whole. This may suggest some kind of overall organization that pulls it all together. Then recite, using the questions or other cues as starters or stimuli for recall. This latter kind of recitation can be carried out in a few minutes, and should be done every week or two with important material.

"M.U.R.D.E.R."

A Study System

- Mood, Understand, Recall, Digest, Expand, Review

- **Mood:**

Set a *positive* **mood** for you to study in.
Select the appropriate time, environment, and attitude

- **Understand:**
  Mark any information **you don't understand** in a particular unit;
  Keep a focus on one unit or a manageable group of exercises

- **Recall:**
  After studying the unit,
  stop and put what you have learned **into your own words**

- **Digest:**
  Go back to what you did not understand and **reconsider the information**;
  Contact external expert sources (e.g., other books or an instructor) if you still cannot understand it

- **Expand:**
  In this step, ask **three kinds of questions** concerning the studied material:

- If I could speak to the author, what questions would I ask or what criticism would I offer?

- How could I apply this material to what I am interested in?

- How could I make this information interesting and understandable to other students?

- **Review:**
  Go over the material you've covered,
  Review what strategies helped you understand and/or retain information in the past and apply these to your current studies

Weekend

Using the text and notebook, make a Table of Contents - list all the topics and sub-topics you need to know from the chapter.
From the Table of Contents, make a Study Sheet/ Spatial Map.
Recite the information orally and in your own words as you put the Study Sheet/Map together.

Now that you have consolidated all the information you need for that chapter, periodically review the Sheet/Map so that at test time you will not have to cram.

Using Memory Effectively

The following techniques and exercises use associations with letters, images, maps, etc to help you remember.
As you proceed through this list of techniques, try to think of strategies that would be useful to you!
Some people use letters, some images, and even, songs.
Each depends on how comfortable you are, or how useful they are to, your way of thinking!

3. Acronyms (MNEMONICS)

An acronym is an invented combination of letters. Each letter is a cue to, or suggests, an item you need to remember.

BODMAS, A sequence in solving or evaluating math problems
Brackets**/O**f/**D**ivision/**M**ultiplication/**A**ddition/**S**ubtraction

ROY G. BIV, the colors of the visible spectrum
Red, **O**range, **Y**ellow, **G**reen, **B**lue, **I**ndigo, **V**iolet

IPMAT, the stages of cell division
Interphase, **P**rophase, **M**etaphase, **A**naphase, **T**elephase

Practice your acronym

4. **An acrostic** is an invented sentence or poem with a first letter cue:
   The first letter of each word is a cue to an idea you need to remember.

   Please Excuse My Dear Aunt Sally (PEMDAS, above**)**
   Sequence in solving or evaluating math equations
   Parenthesis **|** **E**xponents **|** **M**ultiplication **|** **D**ivision **|** **A**ddition **|** **S**ubtraction

   Every Good Boy Deserves Fun
   An acrostic for remembering a sequence of musical notes (G-clef notes on sheet music)**--E, G, B, D, F**

Practice your acrostic!

5. **Rhyme-Keys: (for ordered or unordered lists)**

First, memorize key words that can be associated with numbers.

Example: bun = one; shoe = two, tree = three, door = four, hive = five, etc.
Create an image of the items you need to remember with key words.
Four basic food groups-- diary products; meat, fish, and poultry; grains; and fruit and vegetables

Think of cheese on a bun (one), livestock with shoes on (two),

a sack of grain suspended in a tree (three), a door to a room stocked with fruits and vegetables (four)

Practice your rhymes

6. **The Method of Loci: (for approximately twenty items)**

Select any location that you have spent a lot of time in and know well.
Good for kinesthetic learners!

Imagine yourself walking through the location, selecting clearly defined places-- the door, sofa, refrigerator, shelf, etc. Imagine yourself putting objects that you need to remember into each of these places by walking through this location in a direct path.

Again, you need a standard direct path and clearly defined locations for objects to facilitate the retrieval of these objects.

George Washington, Thomas Jefferson, and Richard Nixon, you could imagine walking up to the door of your location and seeing a dollar bill stuck in the door; when you open the door Jefferson is reclining on the sofa and Nixon is eating out of the refrigerator.

Practice your loci

7. **The Keyword Method: (for foreign language vocabulary)**

First, after considering the foreign word you need to remember, select a key word in English that sounds like the foreign word.
Next, imagine an image, which involves the key word with the English meaning of the foreign word.
For example, consider the Spanish word "cabina" which means "phone booth." For the English keyword, you might think of "cab in a ...." You could then invent an image of a cab trying to fit in a phone booth. When you see the word "cabina" on the test, you should be able to recall the image of the cab and you should be able to retrieve the definition "phone booth."

Practice your keywords

8. **The Image-Name Technique: (for remembering names)**
   Simply invent any relationship between the name and the physical characteristics of the person. For example, if you had to remember Shirley Temple's name, you might ingrain the name in memory by noticing that she has "curly" (rhymes with Shirley) hair around her temples.

Practice image naming

9. **Chaining: (for ordered or unordered lists)**
   Create a story where each word or idea you have to remember cues the next idea you needs to recall. If you had to remember the words Napoleon, ear, door, and Germany, you could invent a story of Napoleon with his ear to a door listening to people speak in German.

Practice you're chaining

Designing Mnemonics: Imagination, Association and Location

The three fundamental principles underlying the use of mnemonics are **imagination, association, and location.** Working together, you can use these principles to generate powerful mnemonic systems.

Imagination: is what you use to create and strengthen the associations needed to create effective mnemonics. Your imagination is what you use to create mnemonics that are potent for you. The more strongly you imagine and visualize a situation, the more effectively it will stick in your mind for later recall. The imagery you use in your mnemonics can be as violent, vivid, or sensual, as you like, as long as it helps you to remember.

Association: this is the method by which you link a thing to be remembered to a way of remembering it. You can create associations by:

- Placing things on top of each other
- Crashing things together
- Merging images together
- Wrapping them around each other
- Rotating them around each other or having them dancing together
- Linking them using the same color, smell, shape, or feeling

As an example, you might link the number 1 with a goldfish by visualizing a 1-shaped spear being used to spear it.
Location: gives you two things: a coherent context into which you can place information so that it hangs together, and a way of separating one mnemonic from another. By setting one mnemonic in a particular town, I can separate it from a similar mnemonic set in a

city. For example, by setting one in Wimbledon and another similar mnemonic with images of Manhattan, we can separate them with no danger of confusion. You can build the flavors and atmosphere of these places into your mnemonics to strengthen the feeling of location.

LEARNING DIAGRAMS

- Diagrams can be learnt by just looking at them as you are studying.
- Look at the diagram until you form a picture in your mind.
- Hide the diagram and draw it exactly as you see it in your mind's eye.
- Compare your diagram with the original diagram and check where you made mistakes.
- Look at the diagram for the second time this time concentrating on where you made mistakes.
- Put the diagram away and try to draw it again.
- Compare your second diagram to your first diagram and the original one to check which mistakes have been repeated and where you made improvements.
- Do the same processes until you draw a correct well-labeled diagram without looking at or tracing the diagram

LEARNING SCIENTIFIC DEFINITIONS

- Physical science learning has to go with knowing scientific facts
- Facts have to be memorized with an attached meaning – since memorizing facts without knowing their meaning leads to rote learning.
- Scientific concepts, principles and laws are belt on facts
- Definition of a scientific term should start from knowing its meaning in English (its literal meaning) – therefore consult a dictionary for its literal meaning.
- Where possible turn it into symbolic or word form.
- Paraphrase the definition into your own words.

- Where possible include a diagram – which could be used to aid your memory when defining it from memory.

LEARNING DESCRIBING EXPERIMENTS

STEP 1
- Describe the aim of the experiment

STEP 2
- List down materials to be used in the experiment

STEP 3
- Draw a relevant well-labeled diagram if applicable

STEP 4
- *** Describe the procedure step by step

STEP 5
- Indicate any expected results/observations from the experiment.

STEP 6
- Interpret and conclude the results/observations

Tips for Better Test Taking

When you take a test,

- you are demonstrating your ability to understand course material or perform certain tasks. Successful test taking avoids carelessness.

- These suggestions may help you avoid careless errors!

- **A. PREPARATION**

- Analyze your past test results
  Each test can further prepare you for the next test.
  Use your tests to review when studying for final exams

Arrive early for tests

- Bring all the materials you will need such as a pencil and a pen, a calculator, a dictionary, and a watch.
  This helps you focus on the task at hand

- **Be comfortable but alert**
  Choose a good spot and make sure you have enough room to work, maintain comfortable posture but don't "slouch"

- **Stay relaxed and confident**
  Remind yourself that you are well prepared and are going to do well. If you find yourself anxious, take several slow, deep breaths to relax
  Don't talk about the test to other students just before it; anxiety is contagious

-
  B. TEST TAKING

- Read the directions carefully
  This may be obvious, but it will help you avoid careless errors

- If there is time, quickly look through the test for an overview
  Note key terms, jot down brief notes

- **Answer questions in a strategic order:**

- First easy questions
  to build confidence, score points, and mentally orient yourself to vocabulary, concepts, and your studies (it may help you make associations with more difficult questions)

    10. **Then difficult questions** or those with the most point value
        With objective tests, first eliminate those answers you know to be wrong, or are likely to be wrong, don't seem to fit, or where two options are so similar as to be both incorrect
        With essay/subjective questions, broadly outline your answer and sequence the order of your points

C. REVIEW

Resist the urge to leave as soon as you have completed all the items
Review your test to make sure that you have answered all questions, not mis-marked the answer sheet, or made some other simple mistake
Proof read your writing for spelling, grammar, punctuation, decimal points, etc.

Change answers to questions if you originally misread them
or if you have encountered information elsewhere in the test that indicates that your first choice is incorrect

Decide on and adopt study strategies that worked best for you
identify those that did not work well and replace them.

Time Management

Developing time management skills is a journey

that may begin with this Guide, but needs practice and other guidance along the way.

One goal is to help yourself become aware of how you use your time
as one resource in organizing, prioritizing, and succeeding in your studies
in the context of competing activities of friends, work, family, etc.

Strategies on using time:

Develop blocks of study time
About 50 minutes? How long does it take for you to become restless?
Some learners need more frequent breaks for a variety of reasons
More difficult material may also require more frequent breaks

Schedule weekly reviews and updates

Prioritize assignments
When studying, get in the habit of beginning with the most difficult subject or task

Develop alternative study places free from distractions
to maximize concentration

Got "dead time"?
Think of using time walking, riding, etc. for studying “bits”

- Review studies and readings just before class
- Review lecture material immediately after class
  (Forgetting is greatest within 24 hours without review)
- Schedule time for critical course events
  Papers, presentations, tests, etc.
-

Develop criteria for adjusting your schedule
to meet both your academic and non-academic needs

Effective aids:

- "To Do" list

➢ Write down things you have to do, then decide what to do at the moment, what to schedule for later, what to get someone else to do, and what to put off for a later time period

- Daily/weekly planner

➢ Write down appointments, classes, and meetings on a chronological logbook or chart.
If you are more visual, sketch out your schedule
First thing in the morning, check what's ahead for the day
always go to sleep knowing you're prepared for tomorrow

- **Long term planner**

➢ Use a monthly chart so that you can plan.
Long term planners will also serve as a reminder to constructively plan time for yourself

Preparing for Essay Style Exams

Doing well on Essay Exams

IDENTIFY

The first group comprises question words, which elicit direct answers and may tend not to elicit developed answers. Consequently, they may be rarely seen on essay exams. Nonetheless, they appear, and when they do, they often imply that the student should explain or elaborate.

- *** LIST** *- Write an itemized series of concise statements

- *** DESCRIBE *** - Recount, characterize, sketch, relate in a sequence or story form.

- *** DEFINE *-**Give clear, concise, authoritative meanings.

- *** STATE** *- Present main points in brief, clear sequence, usually omitting minor details and examples.

- **SUMMARIZE** - Give the main points or facts in condensed form, like the summary of a chapter in a text, omitting details and illustrations.

- *** DIAGRAM *** - Give a graphic answer, a drawing, a chart, a plan, a schematic representation.

EXPLAIN

As a group, these words tend to suggest fully thought out and demonstrated answers. These terms tend to be a little slippery and it is often advisable to clarify the meaning of these words within the context of your course.

- **DISCUSS** - Consider various points of view, analyze carefully, and give reasons pro and con.

- *** ANALYZE *** -Summarize fully with detail in accordance with a selected focus, consider component parts of ideas and their inter-relationships

- *** EXPLAIN *** - Clarify, interpret, give reasons for differences of opinion or of results, and analyze causes.

- *** ILLUSTRATE** *- Use a word picture, diagram, or concrete example to clarify a point.

- **OUTLINE** - Organize a description based on main points and subordinate points, stressing the arrangement and classification of the subject matter.

- **TRACE** - In narrative form, describe the evolution, development, or progress of the subject.

COMPARE

These action words are premised on an analysis which works to integrate ideas under focus; emphasizing similarities, differences, and connections between these ideas deepens our understanding of the ideas and may help you contextualize ideas more effectively.

- **COMPARE-** Look for qualities or characteristics that resemble each other. Emphasize similarities, but also note differences.

- **CONTRAST** - Stress differences, dissimilarities of ideas, concepts, events, problems, etc., but also note similarities.

- **RELATE** - Show how ideas or concepts are connected to each other.

- Related words: **DISTINGUISH.**

ARGUE

The words in this group direct the student to take a position on an issue and defend his or her argument against reasonable alternatives.

- **PROVE** - Establish the truth of a statement by giving factual evidence and logical reasoning.

- **JUSTIFY -** Show strong reasons for decisions or conclusions; use convincing arguments based on evidence

- Related words: **AGREE, DISAGREE, DEBATE, DEFEND**

ASSESS

Writing an essay question with these action words involves invoking acceptable criteria and defending a judgment on the issue, idea, or question involved. Underlying questions here include "to what extent?" and "how well?"

- **EVALUATE** - Appraise, give your viewpoint, cite limitations and advantages, include the opinion of authorities, and give evidence to support your position. (cf., CRITICIZE)

- **INTERPRET -** Translate, give examples, or comment on a subject, usually including your own viewpoint.

LEARNING WITH A STUDY GROUP

- An effective group usually has 3 to 6 members, who are serious about doing well but otherwise; do not know each other well.

- The groups meet at least once a week – Thursday, Friday and Saturday.

- Members of effective groups complete tasks before each meeting and each meeting has an agenda

Functions of the group;

- Review copies of each other lecture notes to fill in gaps.

- Review outlines of textbook chapters and noting areas that are unclear.

- Completing and reviewing assignments and explaining or reviewing additional problems or questions in preparation for exams.

Preparation for midterms and finals;

- Study for exams and do problems.

- Developing outlines of important material with each member preparing outlines on specific topics.

- Using index cards as study aids, specifically for facts and definitions of terms.

- Practicing answering questions and problems like those that are likely on the exam with each member preparing problems and solutions

- Simulating exam conditions and reviewing past exams.

- Meet at a place there every member is happy with which has very minimal disturbances.

- Members should regularly and each member should do his/her fair share.

END OF THE PROGRAM

APPENDIX D

Two-way Analysis of covariance

Four variables were involved;

- ❖ Two categorical independent variable with two levels

1. Group	a. Experimental
	b. Control
2. Gender	a. Female
	b. Male

- ❖ One continuous independent variable

  3. Posttest scores

- ❖ One continuous covariate variable

  4. Pretest scores

Coding

Variable name	**Variable label**	**Coding instructions**
Group	Type of group	2 = Experimental group 3 = Control group
Gender	Sex	0 = Boys 1 = Girls
Pretest	Pretest scores	Total score on the pretest administered before the beginning of the

		implementation of the intervention. High score implies greater achievement and vice versa.
Posttest	Posttest scores	Total score on the posttest administered after the implementation of the intervention. High score implies greater achievement and vice versa.

Procedure for two-way ANCOVA

Using SPSS:

1. Click on ‘analyze’.
2. Click on ‘General Linear Model’.
3. Click on ‘Univariate’.
4. Move dependent variable (posttest scores) into ‘dependent variable box’.
5. Move the two independent variables (Group and Gender) into ‘fixed factor box’.
6. Move the covariate variable (pretest scores) into the ‘covariate box’.
7. Click ‘model button’ – click on ‘full factorial’ in the ‘specify model’ section and click ‘continue’.
8. Click ‘options’.
9. In the section labeled ‘estimated marginal means’, click on the first independent variable (group) and move it into a box labeled ‘display means for’.
10. Do the same for the second independent variable.
11. Click on the extra interaction term (group * gender) and move it into the box.

12. In the option section, click on ‘descriptive statistics’, ‘estimates of effect size’, 'observed power’ and ‘homogeneity tests’ and click ‘continue’.
13. Click on ‘plots’.
14. Highlight the first independent variable and move it to a box labeled ‘horizontal’.
15. Highlight the second independent variable and move it to a box labeled ‘separate lines’.
16. Click on ‘add’.
17. Click, on ‘continue’ and then ‘OK’.

APPENDIX E

Independent sample t-test on the residualized gain scores

Basing on the pretest and posttest scores of the control group, correlation coefficient was calculated.

Using SPSS:

Procedure for calculating Pearson product-moment correlation

1. Click ‘analyze’.
2. Click on ‘Correlate’ and then ‘Bivariate’.
3. Select the two variables (pretest and the posttest scores) and move them into a box marked ‘Variables’.
4. Click on the ‘option’ button

   - For ‘missing values’, click on the ‘Exclude cases pairwise’ box.
5. Click ‘continue’ and ‘OK’

Procedure for predicting posttest scores

Prediction of the posttest score of each member used the following equation;

$$y' = bx_i + c$$

Whereby y' is the predicted score

b is the correlation between the pretest and the posttest scores of the control group (0.5)

x_i is the pretest raw score

c is the y-intercept in a graph of pretest scores against posttest scores of the control group (3.9)

Procedure for calculating residualized gain score

The predicted scores were being subtracted from the posttest scores for each member of a group. i.e.

Residualized gain score = Posttest score – predicted score (for each member in each group)

Procedure for conducting an independent sample t-test on the residualized gain scores

Using SPSS

1. Click on ‘analyze’.
2. Click on ‘Compare means’.
3. Click on ‘Independent sample t-test’.
4. Move the independent variable (group) into the box labeled ‘Grouping variable’.
5. Click on ‘define groups’ – type in the codes used for posttest scores of the groups; for example 2 for experimental group scores and 3 for the control group scores.
6. Click ‘continue’ and ‘OK’.

APPENDIX F

Partial correlation coefficient

Three variables were involved;

- ❖ Two variables that their relationship was explored (age and posttest scores)
- ❖ One variable that was controlled for (pretest scores)

Procedure for calculating partial correlation

Using SPSS

1. Click on ‘analyze’.
2. Click on ‘Correlates’.
3. Click on ‘Partial’.
4. Click on the two variables that their relationship was explored (age and posttest scores) and move them to the ‘Variable’ box.
5. Click on the variable that is being controlled for (pretest scores) and move it to the ‘Controlling for’ box.
6. Choose one or two tail significance
7. Click on ‘Options’.
    8. In the missing values section click on ‘Exclude cases pairwise’.
    9. In the statistics section click on ‘zero order correlations’.
10. Click ‘continue’ and ‘OK’

APPENDIX G

Point biserial correlation

Involved two variables;

- One continuous variable (pretest/posttest scores)
- One categorical variable (gender)

Coding

Variable name	Variable label	Coding instructions
Pretest/posttest scores	scores	Total score on the pretest/posttest. High score implies greater achievement and vice versa
Gender	sex	0 = boys 1 = girls

Procedure for calculating point biserial correlation

Using excel [data entered]

1. Enter '='
2. Click 'function' [f_x]
3. Select 'all' in a select category box.
4. Select 'correl' in the select a function box.
5. Click 'OK'.
6. Type the range of the categorical variable [gender]eg A1:A110 in 'Array 1' box
7. Type the range of the continuous variable [pretest/posttest scores]eg B1:B110 in 'Array 2' box.

8. Click ‘OK’.

Or

Use the following equation;

$$r_{pb} = \frac{\overline{Y}_1 - \overline{Y}_0}{\delta_Y}\sqrt{pq}$$

Whereby; $\overline{Y_1}$ is the mean for girls in the pretest/posttest in either experimental or control group.

$\overline{Y_0}$ is the mean for boys in the pretest/posttest in either experimental or control group.

δ_Y is the standard deviation for all the pretest or posttest scores for both the girls and the boys.

p is the proportion of girls

q is the proportion of boys

APPENDIX H

Calculation of chi-square statistic for the metacognitive learning strategy use in the experimental and control groups

	True of me		Not sure		Not true of me		Totals
	Observed	Expected	Observed	Expected	Observed	Expected	
Learning skill given	68	57.98	27	24.41	143	155.62	**238**
Learning skills not given	46	56.02	21	23.59	163	150.38	**230**
Totals	**114**		**48**		**306**		**468**

O	E	$(O-E)$	$(O-E)^2$	$\frac{(O-E)^2}{E}$
68	57.98	10.02	100.40	1.73
46	56.02	-10.02	100.40	1.79
27	24.41	2.59	6.71	0.27
21	23.59	-2.59	6.71	0.28
143	155.62	-12.62	159.26	1.02
163	150.38	12.62	159.26	1.06

$$\chi^2 = \mathbf{6.166}$$

$$\chi^2_{cv} = \mathbf{5.991}$$

Calculation of expected frequencies

$$\text{Expected frequency} = \frac{f_r f_c}{n} \quad \text{whereby } f_r \text{ is the total row frequency}$$

f_c is the total column frequency

n is the total frequency

Calculation of standardized residuals

$$R = \frac{O-E}{\sqrt{E}} \quad \text{whereby } R \text{ is the Standardized residual}$$

O is the observed frequency

E is the expected frequency

APPENDIX I

Calculation of chi-square statistic for the self-regulated learning strategy use in the experimental and control groups

	True of me		**Not sure**		**Not true of me**		**Totals**
	Observed	expected	Observed	Expected	observed	expected	
Learning skill given	63	56.38	9	15.2	79	79.42	**151**
Learning skills not given	52	58.67	22	15.8	83	82.58	**157**
Totals	**115**		**31**		**162**		**308**

O	E		$(O-E)^2$	$\frac{(O-E)^2}{E}$
63	56.38	6.62	43.82	0.78
52	58.67	-6.67	44.49	0.76
9	15.2	-6.2	38.44	2.53
22	15.8	6.2	38.44	2.43
79	79.42	-0.42	0.18	0.00
83	82.58	0.42	0.18	0.00

$$\chi^2 = \mathbf{6.502}$$

$$\chi^2_{cv} = \mathbf{5.991}$$

Calculation of expected frequencies

Expected frequency $= \frac{f_r f_c}{n}$ whereby f_r is the total row frequency

f_c is the total column frequency

n is the total frequency

Calculation of standardized residuals

$R = \frac{O-E}{\sqrt{E}}$ whereby R is the Standardized residual

O is the observed frequency

E is the expected frequency

APPENDIX J

THE STUDENTS LEARNING STRATEGY USE QUESTIONNAIRE

INTRODUCTIONS

Dear Student,

I am conducting an experimental research on whether teaching students learning skills would improve performance in senior secondary school Physical science. The purpose of my study is to improve academic performance in Physical science through teaching of the learning skills.

You have been identified to assist in this research. The information you will provide will be treated with its due confidentiality. Please note that there are no wrong or right answers to these questions. All what is required is you opinion.

Use the number you have been using during the pretest and the posttest you wrote earlier on in this study and not your name.

Thank you very much for your co-operation.

Name of school____________________ **Student ID number**____________________

Age __________ Years **Sex:** Female _________ Male_____________

Please indicate how strongly you agree or disagree in all of the following statements about how you learn and feel about Physical science by placing a tick in the appropriate box.

STATEMENT	**Not at all true of me**	**Mostly not true of me**	**Not sure**	**True of me**	**Very true of me**
1. When I study for a test, I try to put together the information from class and from the books.					
2. When I do homework, I try to remember what the teacher said in class so I can answer the question correctly.					
3. It is hard for me to decide what the main ideas are in what I read.					

	Not at all true of me	Mostly not true of me	Not sure	True of me	Very true of me
4. When I study, I put important ideas into my own words.					
5. I always try to understand what the teacher is saying even if it does not make sense.					
6. When I study for a test, I try to remember as many facts as I can.					
7. When studying, I copy my notes over again to help me remember the material.					
8. When I study for a test, I practice saying the important facts over and over to myself. .					
9. I use what I have learned from old homework assignments and the textbook to do new assignments					
10. When I am studying for a topic, I try to make everything fit together.					
11. When I read material for Physical science class, I say the words over and over to myself to help me remember					
12. I outline the chapters in my book to help me study.					

	Not at all true of me	Mostly not true of me	Not sure	True of me	Very true of me
13. When reading I try to connect the things I am reading about with what I already know.					
14. When I study for this Physical science class, I put important ideas into my own words.					
15. I ask myself questions to make sure I know the material I have been studying.					
16. When work is hard, I either give up or study only the easy parts.					
17. I work on practice exercises and answer end of chapter questions even when I do not have to.					
18. Even when study materials are dull and uninteresting, I keep working until I finish.					
19. Before I begin studying, I think about the things I will need to do to learn.					
20. I often find that I have been reading for class but do not know what it is all about.					

	Not at all true of me	Mostly not true of me	Not sure	True of me	Very true of me
21. I find that when the teacher is talking I think of other things and do not really listen to what is being said.					
22. When I am reading I stop once in a while and go over what I have read.					
23. I work hard to get a good grade even when I do not like a class.					

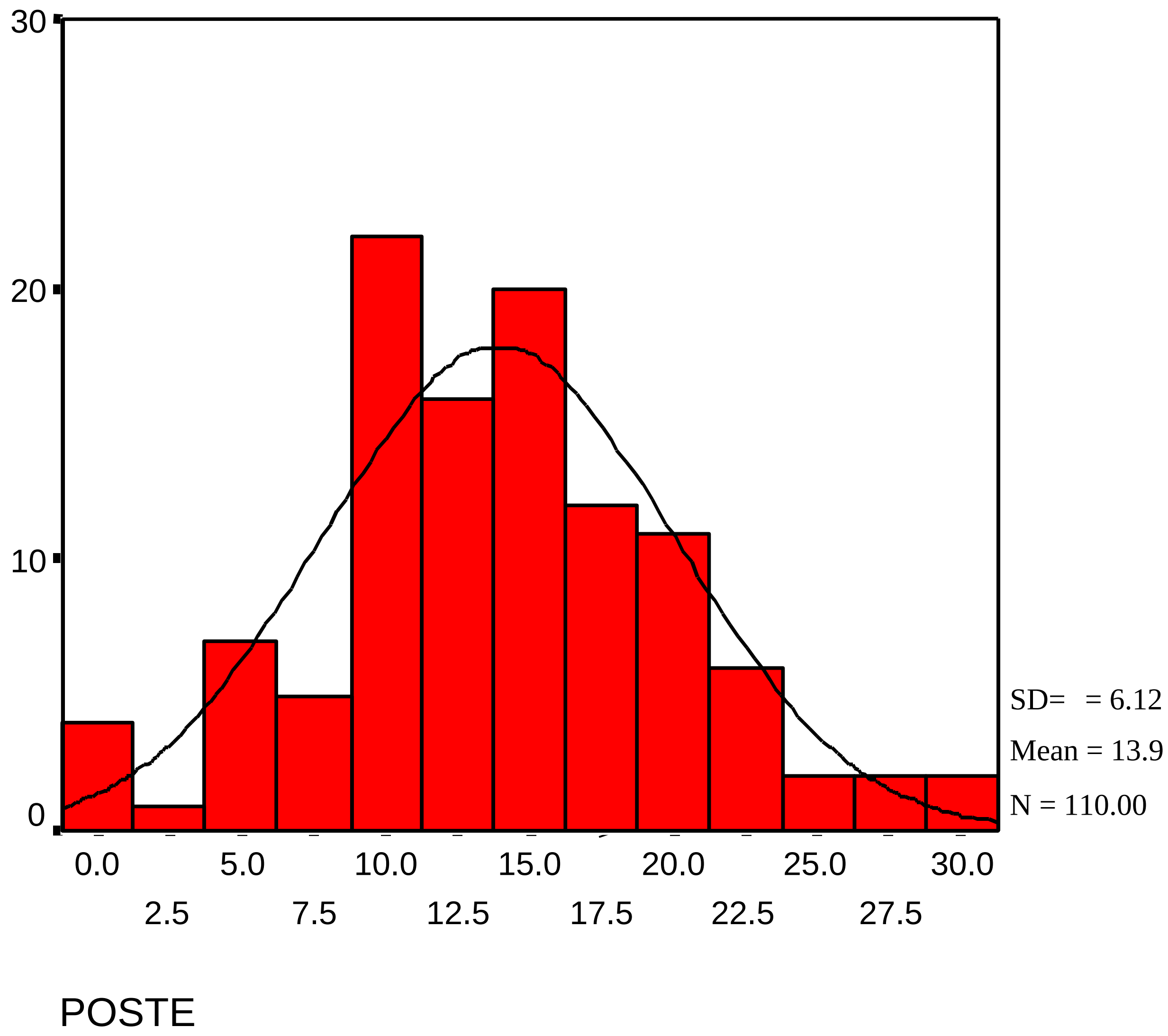
Thank you very much for your co-operation.

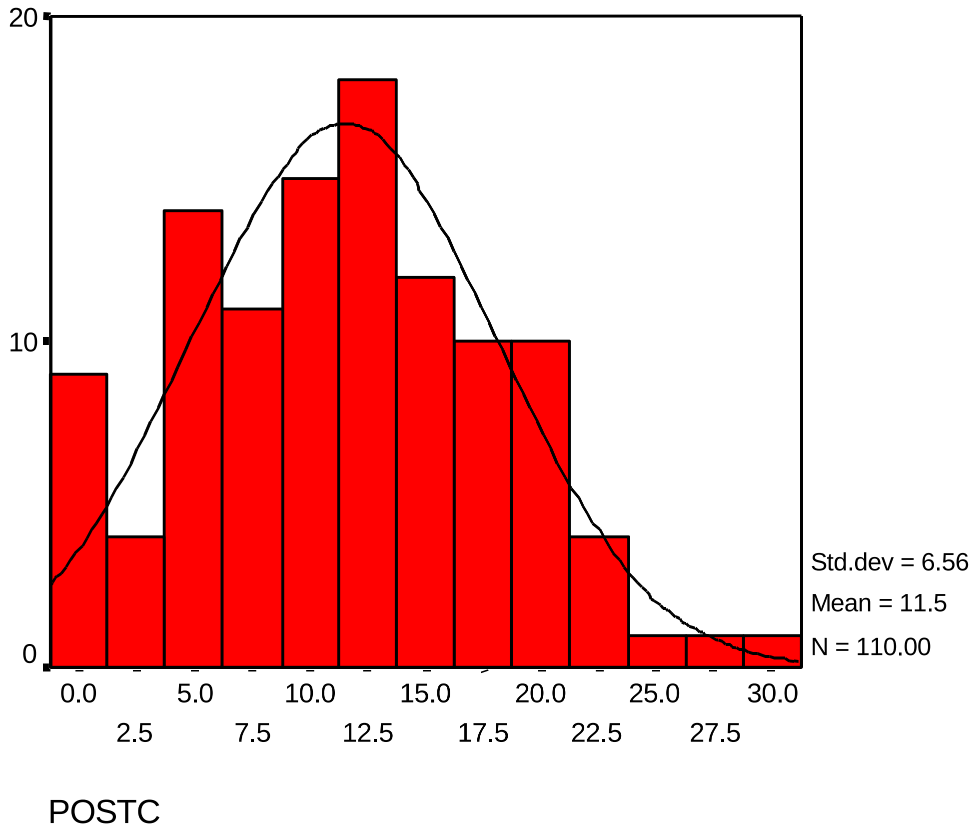
APPENDIX K

A test of the assumption of normality

Group type	Kolmogorov-Smirnov(a)			Shapiro-Wilk		
	Statistic	**df**	**Sig.**	**Statistic**	**df**	**Sig.**
Experimental group	.090	110	.030	.983	110	.167
Control group	.056	109	.200(*)	.982	109	.139

The assumption of normality is observed in the control (sig. = 0.200) while in the experimental group (sig. = 0.030) it is not. The histograms below show the distribution of scores in the control and the experimental groups.

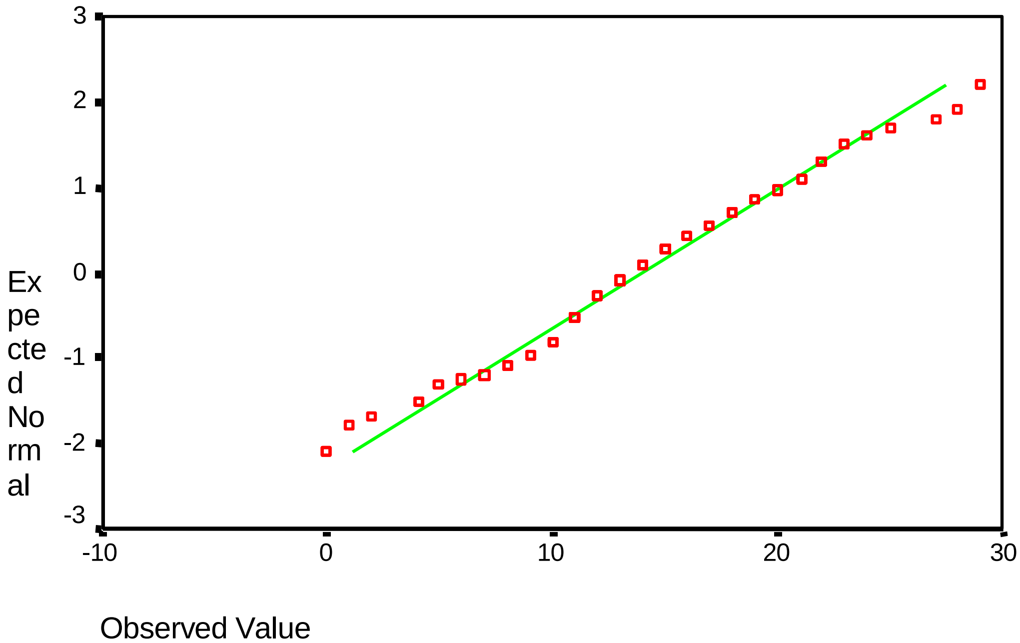

30
20
10
0
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
22.5
25.0
27.5
30.0
SD= = 6.12
Mean = 13.9
N = 110.00
POSTE

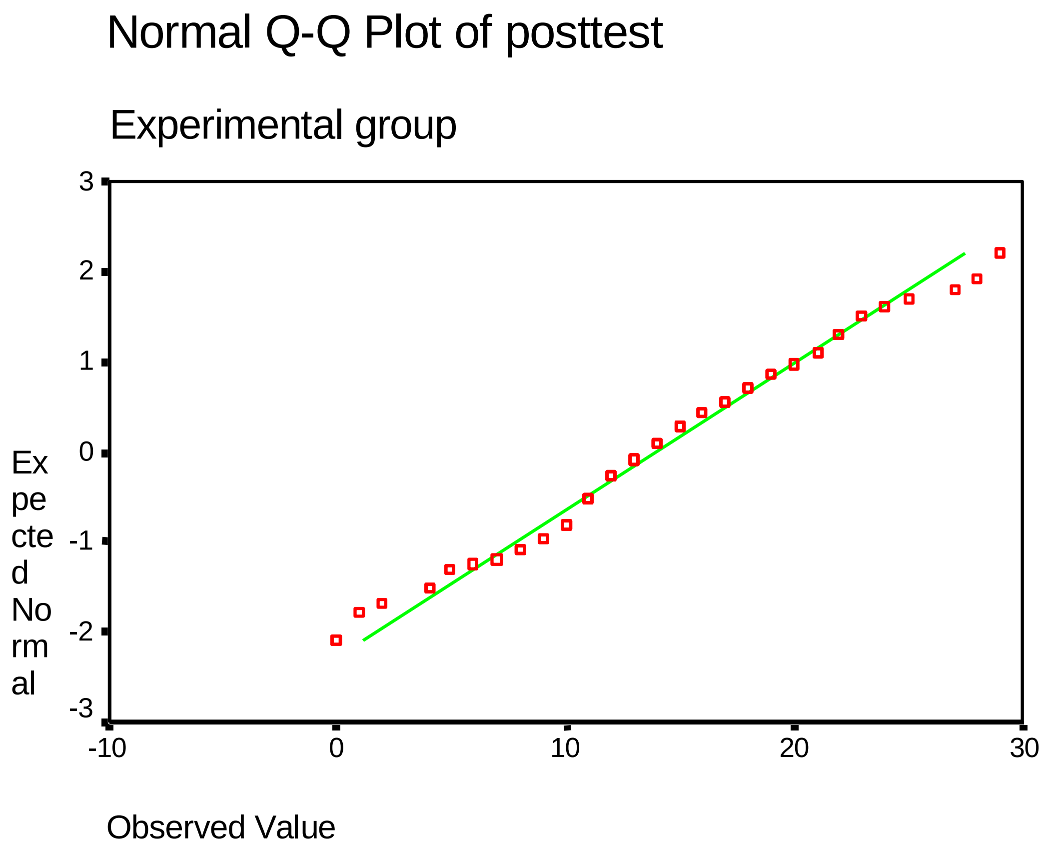


The shapes of the histograms appear to be reasonably normally distributed. The normal probability plots shows reasonably straight line, which suggest a normal distribution.

Normal Q-Q Plot of posttest

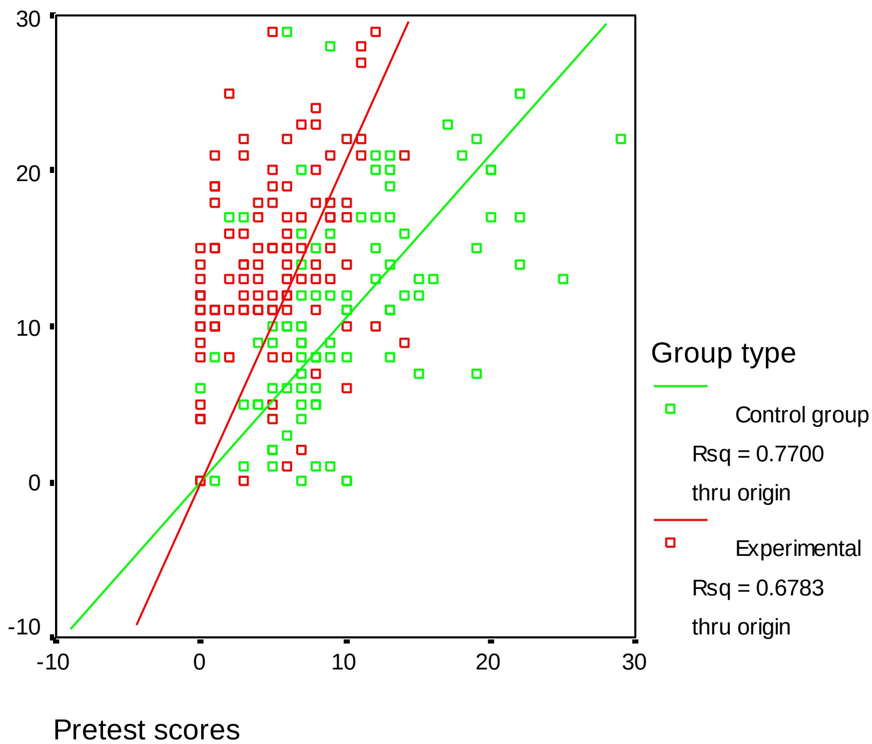
Experimental group




Normal Q-Q Plot of posttest
Experimental group
Expected Normal
3
2
1
0
-1
-2
-3
-10
0
10
20
30
Observed Value

APPENDIX L

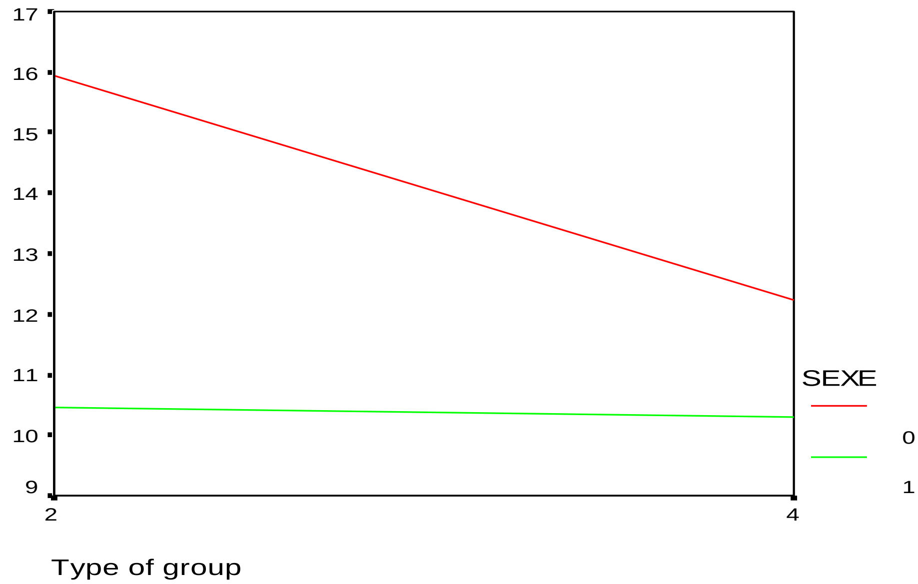
A test of an assumption of linearity between posttest (dependent variable) and pretest (covariate)



R^2 for the experimental group (0.77) show that 77 % of the variance in the posttest scores can be explained by the variance in the pretest scores. R^2 value (0.68) shows that 68% of the variance in the posttest scores can be explained by the variance in the pretest scores.

APPENDIX M

A graph showing group means for male and female students



The mean scores of the female students were consistently lower than the mean scores of the male students.

APPENDIX N