

**INFLUENCES OF CREATIVITY TEACHING STRATEGY ON STUDENTS
PERFORMANCE AND MOTIVATION IN THE TOPIC 'ENERGY' IN
SECONDARY SCHOOL PHYSICS IN NAKURU DISTRICT, KENYA**

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**A Thesis Submitted to the Graduate School in Partial Fulfillment of the Requirements
for the Award of a Degree in Master of Education (Science) of Egerton University**



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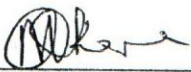
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DEDICATION

This work is dedicated to my entire family for the relentless support and encouragement I received in the course of the study. Special dedication goes to my wife Monica; son Elvis Hungi and mum Rahab Wangui who gave me both moral and psychological impetus to conclude my studies successfully.

ACKNOWLEDGEMENTS

I would like to register my heartfelt appreciation to the Ministry of Education through the DEO's office Nakuru District for allowing me to carry out the study within the district. This Thesis was prepared under the relentless supervision and support of Professor Okere and Professor Changeiywo both from the Department of Curriculum, Instruction and Educational Management, Egerton University. I would like to thank them for their guidance and encouragement which they afforded me during the study. To all the entire staff at the Department of Curriculum, Instruction and Educational Management; at the Faculty of Education and Community Studies and at the Graduate School, Egerton University who offered me any form of support in the course of the study, I say thank you. I would also wish to acknowledge the companionship of one of my colleagues Richard Owino with whom I exchanged notes most of the times and gave encouragement to each other in the course of the study. I am also greatly indebted to Mr. Muturi, M, the principal, Subukia Day Secondary School and the entire teaching and non-teaching staff in the same school who in one way or another gave me moral support and invaluable counsel. Also all the principals in various secondary schools within the district who allowed my study to be carried out in their schools are acknowledged. The various Physics teachers who gave me invaluable advice and directions in the course of the study have a special place in my heart. Much thanks go to Mr. P. Waweru of St. Yermo, Mr. Wachira of Kiamaina, Mr. A. Chepkwony of Wei, Mrs. R. Nguro of Kieni and Mr. L. Wachira of Menengai High School for having accepted to take part in the study either by teaching the modules or collecting the research data from the students. My entire family members and friends who may have played a crucial role in one way or another to help me in my study impetus are hereby acknowledged. Finally I thank the Graduate School, Egerton University for granting me Research Fund which went a long way in facilitating my research process.

ABSTRACT

There's a need to train our students in creative skills that would enable them plan for a scientific investigation, show sensitivity towards scientific problems, show flexibility in reasoning and relate concepts and ideas. This is because researches conducted in Kenyan secondary schools indicate low levels of creativity in science subjects in general. Such skills may be taught through a Creativity Teaching Strategy (CTS). At the same time the number of candidates taking physics examination at Kenya Certificate of Secondary Education (K.C.S.E) level has dropped gradually to less than one third of the total candidature. This could partly be due to low motivation, poor performance and the abstract nature of the subject. This is happening at a time when Physics education in secondary schools has been re-emphasized due to the realization of the role it could play in the industrial and technological development of the country. The purpose of this study was therefore to develop a creativity teaching module for the topic 'energy', which cut across all science subjects and find its influence on learner motivation and creative skills of sensitivity and planning among Form Three Physics students in Nakuru District. Solomon three-quasi experimental group design was used to obtain a sample of the students in three co-educational secondary schools through random assignment. The Experimental Group E and Second Control group C₂ were treated following the prepared creativity modules for a period of three weeks while the True Control group C₁ was not. A Physics Self Assessment Questionnaire (PSAQ) accompanied both the pretest and the posttest. The PSAQ, pretest and posttest instruments were piloted and their validity and reliability established. Data collected from the tests were analysed using the t-test and ANOVA, while chi square was used to analyse the data obtained from the PSAQ questionnaires. Hypotheses were tested at a significance level of $\alpha = 0.05$. Results showed that Creativity Teaching Strategy influenced learners' motivation and creative skills of planning and sensitivity significantly. The results would be useful to curriculum planners in the educational system when considering changes in curriculum and to physics teachers in their daily teaching practises.

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LIST OF ABBREVIATIONS AND ACRONYMS

A Level	High school (advanced level) between form five and form six in the 7 4 2 3 education system.
ASEI-PDSI	Activity Student centered with Experiment and Improvisation-Plan Do See Improve
B ED	Bachelor of Education
B SC	Bachelor of Science
CTS	Creativity Teaching Strategy
DEO	District Education Officer
IQ	Intelligence Quotient
J	Joule –Standard International (SI) unit for energy or work
K C S E	Kenya Certificate of Secondary Education.
K I E	Kenya Institute of Education
K N E C	Kenya National Examination Council
M O E	Ministry of Education (as in Kenya)
O level	Ordinary Level (i.e. classes between form one and form four) in Secondary School in the 7 4 2 3 education system
PSAQ	Physics Self Assessment Questionnaire
ROK	Republic of Kenya
SAT	Standard Assessment Test
SMASSE	Strengthening Mathematics and Science in Secondary Education
TIQET	Totally Integrated Quality Education and Training
UK	United Kingdom
8:4:4 System	An education system which requires a student to at least spend eight years in primary school, followed by four years in secondary school, and finally four years in the higher education (University)
7:4:2:3 System	An education system consisting of at least seven years in primary education, four years in secondary education, two years in high school and finally three years in the university.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Physics is one of the science subjects currently being offered in the secondary schools curriculum. The main aims and objectives of teaching it to Kenyan secondary school students have been outlined in the preamble of its syllabus (ROK 1999). Okere (1996) outlines some of the aims of teaching Physics to include the following: First, to promote public's scientific knowledge of the physical world, that is to satisfy our curiosity about the world we live in. This is the aim of all sciences. Scientific knowledge helps us to answer such questions as: what is matter composed of? What holds particles of solids together? Why is the sky blue? And many other such related questions. It is necessary that students should be helped to understand the nature of the physical world we live in using appropriate knowledge and simple scientific language. Secondly, Physics should be taught to sharpen logical thinking amongst the youth to enable them think more logically, creatively and clearly in all areas of inventions. This will enable such students to identify testable statements, which is the first step in any scientific investigation. They should also be trained to criticize faulty experimental designs and spot fallacious arguments in Physics. This was the reason why this study was designed; it was to check whether the incorporation of creativity teaching strategy would improve learners' creative skills when faced with novel scientific situations. The third reason for studying Physics and sciences in general is for its applicability in everyday situations, for example in medicine where Physics is applied in radiology; in communication where it has many applications that have improved human life.

Teaching of Physics also promotes a positive scientific attitude in the society which creates curiosity, flexibility, enthusiasm, and ability to plan, design and conduct investigations. The above aims of teaching Physics have been amplified further by the objectives of teaching physics education in secondary schools. Such objectives, as outlined in the Physics syllabus, include preparing learners for self reliance, training and further education. It should also offer varied experiences to learners in order to develop an all rounded individual which will enable them make positive contributions to the society and also equip them with cognitive, psychomotor and affective skills (KIE, 1992). Osborn (1972) outlined some scientific attitudes that a science learner should develop. They include the following: methodological study, scientific thought, openness to new ideas, identification of problems and arriving at

solutions to such problems. Physics should therefore be taught to promote such attitudes. Finally Physics is taught to help solve societal problems; its knowledge should therefore be relevant to modern societal needs. Pupils should be made aware of the applications of Physics in *jua-kali* industry, farming and even in the kitchen. Science teaching and knowledge should not only be interpreted in terms of the effects of science on people's lives, for example in technology, war and automation; it should also be considered in terms of its effects on people's way of reasoning (Okere, 1996).

Scientific knowledge is based on the investigations aimed at establishing the cause of observed phenomena or events. It is now obvious that pupils come to school with some ideas about the physical world which do not conform to the accepted scientific knowledge. Such knowledge should be modified and reconstructed to the acceptable scientific meanings. Pupils should be taught to acquire and apply a new set of established laws and principles to explain the nature of the physical world and also solve everyday problems. An example here is the useful application of Physics laws and principles in technology and the destructive effects of science (Physics) which is evident in the manufacture of sophisticated war equipments which leads to massive destruction like the 1998 Nairobi bomb blast and the Gulf War of 1991 both of which led to massive destruction.

Since Physics is a science subject based on experiments, it affects people's way of reasoning by inculcating critical thinking in them; the laws and principles that govern the behavior of the physical world are investigated in Physics and therefore there is need to inculcate skills of measurements and accurate observations (Sears *et al.*, 1987). The modern scientific philosophy of operationalism lays emphasis on process based teaching approaches as opposed to the content approach; it emphasizes that retention is longer when process based teaching approach is used and also leads to higher transferability of skills from one subject to another. Though the teaching of science and Physics in particular has such important and useful objectives, Physics teachers have always been accused of using archaic and outdated strategies in teaching it (Koulaidis, 1987).

A need is therefore felt for the incorporation of more effective teaching strategies in science subjects especially in Physics to improve on the science literacy, which is quite low and in some cases ranges up to 10% in both developed and developing countries (Solomon, 1995). Some research has been done in Sudan to investigate the effects of a 'modern' approach to

teach science education. The results have shown that such teaching approaches do not improve learners' creativity in science knowledge (Khaleefa *et al.*, 1997). Much of studies conducted in Kenya attest to the same results (Okere 1986, 1991). In general, a meaningful learning situation demands that pupils construct their knowledge; therefore in the course of the learning process, learners should be provided with problematic situations that they can identify as worth thinking about (Gil *et al.*, 1991). The teacher together with teaching materials should constitute the scientific community for a science student (Wheatley, 1991).

Research done worldwide has shown that for most science students in many countries, the reality of school classroom consists of lessons where science is transmitted by the teacher at best, as a set of facts, laws and data (Hewson, 1988). Research in Physics teaching methods have come up with a variety of teaching styles as a result of strong interaction existing between teaching attitudes, competences, schools and society (Ryu, 1984). We can effect changes in teaching strategies by incorporating more effective training of teachers and in-service programmes in educational settings; teachers all over the world have been known to seek for answers on how to cope with their students' problems and their own while teaching science subjects (Bliss, 1993). Science teachers have been blamed on the poor conceptualization of scientific knowledge on their students for a number of reasons which include the following: behaving as information providers unlike teaching students to construct scientific knowledge (Brown, 1982; Vianna, 1994); belief that important aspects of Physics knowledge has to do with manipulation of mathematical symbols (Ryu, 1987); teachers not encouraged to carry out innovations of new curriculum and methodologies, this makes them teach science as 'telling science', unlike teach it as a process or 'a way of thinking' (Gallagher, 1994). Koulaidis (1987) found that science teachers teaching position are quite traditional, giving greater emphasis on presentation of knowledge and pupils abilities in thinking in abstract terms.

In Kenya, the need to have a more efficient educational system has been felt since independence and consequently many educational reforms have taken place with an aim of giving Kenyan students better education that will equip them with basic survival tactics and problem solving approaches in their lives (Odhiambo, 1980; Omulando & Shiundu, 1992). The country has particularly felt a need to improve the science education it offers so as to create a knowledgeable manpower required for its industrial and technological transformation (Republic of Kenya, ROK, 1981; 1999; Gichaaga & Thuo, 2006). Many recommendations

from various commissions of inquiry into the educational system of Kenya have aimed at incorporating emerging challenges into the school curriculum in order to prepare the youth for the future (ROK, 1999). The change from the previous 7:4:2:3 education system to the current 8:4:4 education system was to facilitate training of manpower required for industrial and technological transformation of our country by the year 2010. The 8:4:4 system of education was favoured because it was viewed as being broad based with wider subject content and also laid more emphasis on science process skills unlike the previous systems that emphasized more on knowledge and content. The 8:4:4 system of education also laid a lot of emphasis on practical work and therefore it was thought that the system would cater for those pupils who do not study Physics beyond O-level since such practical skills were expected to enable school leavers acquire skills needed in the informal sector which might absorb many of them (ROK, 1981).

A step towards the attainment of such objectives was evident since Physics was offered as a pure science alongside physical sciences in the science curriculum syllabi. A pure Physics syllabus was broader and richer in the knowledge content offered (ROK, 1981). The syllabus also advocated for many projects and field work excursions. The learners were to be provided with skills that will enhance their full participation in the Kenyan industrial and technological sectors (ROK, 1981; 1999). Acquisition of such practical skills among learners can only be facilitated through process based instructional approaches that involve learners in activities that lead to active knowledge construction and enhancement of better knowledge retention (Brown, 1982; Brunner, 1957). Okere (1996) outlines some of the methods considered to be more relevant in teaching Physics to secondary school pupils to include strategies such as constructivist and approaches such as discussion (both class and small group), demonstrations, laboratory experiments, project methods, field trips, excursions and creativity.

But has the Kenyan education system achieved its set objectives of training sufficient manpower for its industrial and technological development? Are the teaching strategies applied across board the most effective and recommended ones? The answers to these questions can only be found by studying the performance of learners in various science subjects in our educational institutions. The performance of learners in science subjects and mathematics has been quite low and for a long time, the average scores in mathematics and physics have remained below grade D in the KCSE national examinations (KNEC analysis, 2000, 2001,

2002, 2003 and 2004). The table below shows a comparison in the average percentage performances of the three science subjects and mathematics at the KCSE level between the year 2001 and 2004:

Table 1: The National Average percentage performance in Mathematics and Science Subjects at the KCSE Level for Years between 2001 and 2004

	Physics	Biology	Chemistry	Mathematics
2001	24.53	31.56	23.38	18.51
2002	28.75	26.46	24.34	19.49
2003	30.68	29.29	26.67	19.08
2004	33.33	35.28	28.11	18.37

(Source: KNEC results analysis, 2002, pp3 & 2004, pp2)

From the table, it is clear that the performance of learners in Physics and the other science subjects is generally low since it ranges between 18% and 35%. This implies that much more effort needs to be put in the educational system in order to better the results. The government, in an attempt to solve the problem of poor performance in science and mathematics in secondary schools has embarked on the SMASSE project, an initiative co-sponsored by the Japanese Government aiming at in-servicing all mathematics and science teachers in the country (Gichaaga & Thuo, 2006). The Activity Student centered with Experiment and Improvisation-Plan Do See and Improve (ASEI-PDSI) instructional strategy being advocated by the SMASSE project draws a lot from and indeed follows the other process based instructional strategies, since it lays greater emphasis on hands and minds on learning activities.

Equally the performance of learners in Physics at the KCSE level in Nakuru district has also been quite low; the performance of learners in physics at the KCSE level in Nakuru district over a number of years is presented in table 2:

Table 2: The Average Performance of Learners at the KCSE Level in Physics in Nakuru District between 2001 And 2004

	2001	2002	2003	2004
Mean score	3.96	4.12	4.80	5.63
Grade	D ⁺	D ⁺	C-	C

(Source: Nakuru District KCSE analysis, 2003 & 2006)

The table clearly shows that the performance of learners at the KCSE level in Physics is quite low in the district. Given that learners are allowed to make a choice of either pursuing physics or dropping it at the level of form two, we expect the overall performance to be better than this (Gichaaga & Thuo, 2006). Similar scores were also recorded in mathematics and other science subjects. Though the average grade in physics was found to be improving, much more could be done to improve the performance. There is therefore need to improve the performance of candidates at secondary school level in science subjects and mathematics. One way of doing this is through investigation of the effects of incorporating other teaching strategies that aim at aiding learners to create knowledge, or construct it, instead of presenting a set of already prepared knowledge to them. One of such approaches is the Creativity Teaching Strategy (CTS). At the same time, researches conducted in Kenya indicate low level of creative abilities among science students (Ndeke, 2003; Okere & Abuto, 2005). Also, lack of motivation amongst Physics students has been noted for many years; this has been against a background that puts a lot of emphasis on applied science education for the country to industrialize by the year 2010 (Gichaaga & Thuo, 2006).

Low level of creativity and motivation amongst Physics students have been attributed to many factors including poor teaching methods and students' inability to organize materials in time allowed for study and retention (Kinyanjui, 1993; KNEC, 2000). Learners need to be taught skills that will enable them become more productive in the industrial and technological sectors of our country. One way of developing such skills is through a Creativity Teaching Strategy which will enable learners show sensitivity towards scientific problems, be flexible in reasoning, and have ability to plan for a scientific problem. The secondary school curriculum objectives lay more emphasis on development of creativity amongst its learners (ROK, 2002). The Koech Commission Report recommended the development of creative and innovative minds (ROK, 1999).

The science process skills are also not receiving adequate attention in Kenyan educational institutions. Various researches have been carried out to find out the level of academic achievement in the acquisition of scientific creativity among Kenyan students and each one of them has shown that the creative ability possessed by learners in Kenyan educational systems is quite low and apparently the educational system and the instructional strategies employed are not inculcating it amongst the graduates of Kenyan educational system. Okere (1991) found that scientific creativity in Physics education is both knowledge and content

dependent; Ndeke (2003) found that creativity in Biology education is affected by gender, knowledge and learning opportunities; while Okere and Abuto (2005) have shown that concept mapping teaching strategy improves performance in learners' creativity in Physics education. Currently creativity teaching strategy is not being used in Kenyan educational system but it is being practiced in some American Universities, for example in Buffalo University. The curriculum planners in Kenya only hope that creative abilities of learners would develop as a result of following the laid down curriculum (ROK, 2002). The tasks set aside for the learners are not sufficient to train them in creativity; teachers should therefore be made aware of the meanings of creativity and how to develop it among learners. They should also be made aware of blocks to creativity and how they can be overcome. Creative ability development objectives should be included in the curriculum and suggestions made on how they should be evaluated. Teaching strategies that foster creativity such as concept mapping should be included in the curriculum so that teachers can practice and master them. Teachers also need to attend in-service course training on meanings and measures of creativity for science education (Okere & Abuto, 2005).

Dermott (1990) has shown that the type of instructional approach used influences motivation in a subject. If the Koech Commission Report recommended the development of creative and innovative minds and this far the educational system is not meeting its end of the bargain, then there's a need to check if creativity can be taught to learners using a set of prepared instructional modules. The study therefore chose the topic on 'Energy' in Secondary School Physics to prepare its creativity teaching modules. This topic was favoured because it cuts across all the science subjects and also it is taught vertically; a learner progressively builds up on the concepts that had been learnt earlier; the content of the topic could be isolated from the rest of the topics in the syllabus and taught to learners with least distraction in the flow of the entire syllabus.

From the above discussions it's clear that learners' performance in Physics is quite poor and there is need to check on it; one of the factors that contribute towards the poor performance of learners in physics as outlined in the above discussions is the instructional strategies applied to teach it. There is therefore need to check whether better performance can be enhanced by the application of a new teaching or instructional strategy in the educational institutions within the district. The study was therefore designed to check whether the incorporation of Creativity Teaching Strategy (CTS) would improve the learners'

performance in the topic. Since the number of students taking physics at KCSE level in the district is on the decline partly due to low motivation and the abstract nature of the subject, the study was also to check whether the incorporation of the CTS in schools will improve learner's motivation in the subject and improve their enrolment in it at the KCSE level.

1.2 Statement of the Problem

It is important that learners are taught to acquire creative skills and motivation to study and pursue Physics to higher levels; there is therefore need to foster the development of creativity skills among Kenyan secondary school students. Lack of scientific creativity skills and motivation among graduates of Kenyan secondary schools have been noted for a long time; low enrollment and poor performance of students in Physics at the K.C.S.E level have also caused some concern amongst educational stakeholders. Lack of creativity skills amongst the graduates of our schools could be attributed to the instructional strategies used in our educational system. Lack of motivation may be responsible for under enrolment and poor performance in Physics. If the current trend (of poor performance and lack of creativity skills among Physics students) is not checked, Kenya may not achieve its set objectives of industrializing by the year 2030 partly because Physics is a key subject in the industrial and technology transformation in our country. The country may also end up having many K.C.S.E. graduates who do not have sufficient scientific knowledge and skills to join tertiary and middle-level science based colleges. A large portion of the population may not have sufficient scientific knowledge to explain or solve problems within their environment. With this realization in mind, it was deemed necessary to develop a creativity instructional module that may enhance students' development of creative ability in their daily learning programmes. The study also investigated whether the incorporation of such a module in teaching the topic 'energy' to secondary school Physics students in Nakuru District would influence their motivation and creativity skills of planning and sensitivity in the topic.

1.3 Purpose of the Study

The purpose of the study was to determine the influence of creativity teaching module on learners' creative abilities of sensitivity towards a scientific problem and planning. The study also sought to establish whether creativity teaching strategy influenced learners' motivation in the topic 'energy'.

1.4 The Objectives of the Study

The following specific objectives guided the study:

- a) To find out the influence of a Creativity Teaching Strategy on learners creativity skill of planning for a scientific investigation in the topic 'Energy'.
- b) To find out the influence of a Creativity Teaching Strategy on learners creativity skill of sensitivity to a scientific problem in the topic 'Energy'.
- c) To find out the influence of Creativity Teaching Strategy on learners motivation in the topic 'Energy'.

1.5 The Hypotheses of the Study

The study sought to establish the following null hypotheses:

- Ho1: Creativity teaching strategy in Physics does not influence the learners' performance when planning for a scientific investigation in the topic 'energy'.
- Ho2: Creativity teaching strategy in Physics does not influence the learners' performance in sensitivity towards a scientific problem in the topic 'energy'.
- Ho3: Creativity teaching strategy in Physics does not influence learners' motivation towards learning about the topic 'energy'.

1.6 Significance of the Study

This study investigated a teaching strategy which, if adopted, could assist learners to improve their creative skills of planning and sensitivity towards a scientific problem. It may also enhance motivation among Physics students as it was able to achieve in the topic 'energy'. The findings of the study would be useful in bringing enlightenment to teachers, Curriculum planners, Education officers and all stakeholders in the education sector on the role the creativity teaching strategy can play in influencing learners' creative skills development. In the course of the study, some of the causes of low creative abilities possession amongst Physics students in Kenya secondary schools were highlighted. The results of the study also

gave useful suggestions to the educational policy makers who give guidance and instructions to the teachers on the best way to present Physics content so as to enhance better knowledge transmission and learner motivation. These findings also add knowledge to Physics teachers about the importance of teaching pupils creatively; this may help teachers to rekindle learners' interest in Physics.

Since the study modified and used Physics creativity teaching modules in the classroom, some invaluable insight into the problems and hurdles that curriculum implementation face at the inception stage have been highlighted. The results of the study may be used as sources of reference material; such knowledge would be useful in teachers' in-service courses, for example in the on-going SMASSE project, where Physics teachers may be challenged to apply the strategy in the course of their teaching. Finally, the end product of the study that is the inculcation of creative abilities amongst the learners cannot be over emphasized; this will go a long way in helping our country achieve some of its set objectives of becoming industrialized by the year 2030 by building up manpower potentials required for the transformation.

1.7 The Scope of the Study

The teaching modules prepared for use in the study covered the content under the topic 'Energy' as outlined in the KIE Physics syllabus and also in the Longhorn Form Three Physics textbook which was used as the main reference material. The module teaching lasted for three weeks, or twelve 40 minutes lessons. The study limited itself to Form Three Physics students in secondary schools within Nakuru District.

1.8 Assumptions of the study

In the generalization of the results, some facts were assumed. First, it was assumed that lack of creative ability among learners depends on the type of instructional approach used by a teacher. Secondly, learners could be taught to be creative and at the same time, some creative activities could be motivating to learners during Physics lessons. Thirdly, teachers were disposed to and willing to use or incorporate a new teaching strategy in an effort to improve their learner's motivation and understanding of concepts in Physics. Fourthly, teachers were assumed to be the best agents to help learners' incorporate creative skills by exposing them to

some creative activities in the best way possible and in an enabling environment. Finally it was assumed that learner's creative abilities could be measured using an instrument that is an open-ended design of investigation questions.

1.9 The Limitations of the Study

The generalization of the results in this study could have been affected by a number of limitations. The first and foremost limitation was that Physics teachers may have interpreted the modules differently due to their individual academic and professional differences. This could have hindered their effective implementation in the teaching-learning situations; therefore the generalization of the results from one context to another was done with caution. Secondly, the prepared creative instructional modules could have appealed to a small group of highly interested and active learners and may have been less interesting to learners with low interest or negative attitude towards Physics. The third limitation is that the sampling technique and the sample size may have affected the generalization since the sample size was relatively small and randomly assigned; it could have affected the generalizability of the result to the target population. Also selection difference, which comes as a result of using groups formed on bases extraneous to the purpose of the study, could have caused interaction effects between selection and certain extraneous variables (for example having bright students or dull ones put in a class room of their own), which could have interfered with the generalization of the results. But the research design and statistical tools used in the data analysis were robust enough to counter any confounding factors that could have affected the validity of the results. Finally since the instructional period was short, the results were generalized with caution; a three-weeks instructional period though long enough for a study to make some observations could have been affected by many confounding factors such as students absence from school and other routine activities, which would have reduced its effectiveness in terms of observable changes.

1.10 Definition of Terms

The following operational definitions of terms were pertinent to this study:

ASEI- PDSI: Activity Student centered with Experiment and Improvisation-Plan Do See Improve. A method of teaching that combines both student centered methods with improvisation in teaching science and mathematics, which is being advocated for in the

on going SMASSE project, an in service course targeting science and mathematics teachers in Kenyan secondary schools.

Creativity: it refers to the ability or power to create or show imaginative skills. In this study, it refers to the ability of a learner to show sensitivity towards a scientific problem and outline his/her plan on how to solve such a problem.

Creativity Teaching Strategy: a teaching strategy that aims at incorporating creative abilities in the learners. In this study it refers to a teaching strategy that incorporates creative activities in form of modules when teaching the physics topic 'energy'.

Creative activities: Activities intended to stimulate learners' imaginative ability. In this study, it refers to activities intended to stimulate learners' creative ability when planning for a scientific investigation and when showing sensitivity to scientific problems in the topic 'energy'.

Flexibility: Learners ability to provide a number of different ways or methods to solve a particular problem. In this study, it refers to the categories of responses given by a respondent.

Instructional module: Independent portion representing the work or the area to be covered during a set time. In this study, it refers to each Physics lesson or session during the creativity instructional period in the topic 'Energy'

Learner-centered teaching: Teaching approaches that emphasize much on learner's maximum participation in a lesson. It has the same meaning in this study.

Likert scale: A scale with a number of points or spaces (usually five) to represent a set of related responses to a given statement, one for each point.

Limitations: It refers to factors that lead to lack of ability. In this study, it refers to an aspect of the study that may negatively affect the results or generalizability of the results, but which could not be controlled for during the study.

Motivation: Refers to stimulation of ones interest; but in this study, academic motivation is implied. Academic motivation here refers to the composite of variables derived from respondents' scores on the four dimensions of motivation to learn Physics.

Motivational level: refers to how high or low ones motivation is; but in this study, it referred to respondents mean score on the twenty items measuring academic motivation to learn the topic 'energy' on a Likert type survey instrument.

N.A.C.C.C.E (UK): National Advisory Committee on Creative and Culture Education; a task force under the department of Education and Employment in London, U.K.

Performance: Refers to achievement; but in this study, it refers to a respondent's score on a

test requiring his/her creativity ability when faced by a scientific problem.

Population: The entire group of individuals or objects with common observable characteristics. In the study, population referred to the Form Three physics students in Nakuru District.

Process based instructional strategies: strategies that involve learners in activities that lead to active knowledge construction.

Sample: A sub-set of the population to which generalization is to be made after data analysis and conclusion has been made. It had the same meaning in the study.

Sampling error: refers to the discrepancy between the sample characteristics and the population characteristics.

Sensitivity: In creativity, it refers to the ability of a learner to recognize a problem and think of possible solutions to the problem.

SMASSE project: Strengthening Mathematics and Science in Secondary Education; an educational project in progress intending to in-service all mathematics and science teachers in Kenya secondary schools on more effective teaching strategies in the subjects.

Systematic error: Variations in characteristics of the population that fluctuates non-randomly.

The Study: Refers to detailed investigation of a subject. In this study, it referred to a scheduled plan of action that intended to give careful examination to the concept of creativity amongst secondary school physics students in Nakuru District.

Teaching strategy: Refers to a plan designed for dealing with an educational matter. In this study, it referred to a procedure that indicates the nature of teacher and learner activities initiated by either and maintained by either of them.

Variable: A measurable characteristic that assumes different values among the subjects.

8:4:4 Education System: A system of education which requires a student to spend eight years in primary school, followed by four years in secondary school, and finally a minimum of four years in the higher education (university). This is the Education System recommended by the Ministry of Basic Education for Kenyan secondary schools.

7:4:2:3 Education System: An education system consisting of at least seven years in primary education, four years in secondary education, two years in high school and finally three years in the university. It was formerly in use in Kenyan secondary schools before the adoption of the current 8:4:4 System of Education.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

In this chapter, the general performance of learners in Physics in Kenya and in other areas has been outlined; the instructional approaches used to teach Physics in secondary schools have also been outlined. The chapter also describes the recent developments in science education that are thought to be more effective in improving learners' performance in Physics. Creativity teaching approach has also been described starting with the various theories and research findings concerning it, its definitions and the forms that it has taken over the years, its relevance in the instructional process; conceptual blocks to its effective incorporation in the educational systems and some of the conceptual block busters. The chapter also describes methods of evaluating creativity, the local situation of creativity in schools and learners' motivation in science and mathematics subjects. Finally the chapter presents the conceptual framework of the study.

2.2 Performance of Learners in Physics at the K.C.S.E. Level in Kenya

As it had been outlined in the background of the study, learners' performance in Physics at the KCSE level is poor (refer to tables 1 and 2 in the background); the on going SMASSE project cycle one in Nakuru district was prefaced thus: "A worrying trend of declining standards in performance of science and mathematics has caused a lot of concern to major stakeholders in the education sector; it is therefore necessary to find ways of changing the trend, and if possible reverse it" (Thuo & Gichaaga, 2004). When compared to the other science subjects, performance in Physics is quite low and this partly explains why many students are shunning Physics and opting for the other science subjects i.e. biology and chemistry.

Against this background of poor performance in Physics, we have to remember that the main objective of the inception of the 8:4:4 education system was to offer an education relevant to the technological and industrial transformation of the country (ROK, 1981). In this case, Physics, alongside the other science subjects, mathematics and technical subjects were considered the key pillars in the achievement of these objectives. Looking at the objectives of

the secondary education syllabus, the 'wholesome' development of an individual is emphasized (ROK, 2002); a KCSE graduate is therefore expected to be an all rounded individual with knowledge and skills to explain, solve problems and handle situations within the environment. But the acquisition of such skills and attitude in the education system has been questioned due to the poor performance of learners in various science, mathematics and technological examinations. Also the level of creativity skills has been found to be low (Okere, 1986; Ndeke, 2003). Most of the science and technology based career courses invariably include Physics as one of the subjects a learner should have passed in before admission; therefore when learners fail in Physics, it means that they are shut off from many science based and technological courses, and consequently the country is denied qualified personnel for its industrial and technological development.

2.3 Factors Contributing to Poor Performance in Physics at KCSE Level

A number of factors have been identified as contributing to poor performance in Physics at the K.C.S.E level. Thuo and Gichaaga (2004) identified some of these problems to include the following: The learner's perception (attitude) towards Physics, the nature of Physics body content where the subject is viewed as being quite abstract and mathematical in its approach; the failure syndrome associated with Physics where the past trend of failures in Physics instills fear of poor performance amongst learners; learners tend to develop fear towards mathematical ideas and expressions, an observation which is evident from the poor performance of learners in mathematics at the KCSE level (KNEC results analysis, 2001, 2002, 2003 & 2004). The instructional approaches applied by Physics teachers also contribute towards poor performance. This is because many teachers still resort to lecture method and dictation of notes to learners instead of using of process based instructional strategies in their teaching.

Changeiywo (2000) gave an insight into the reasons why learners perform poorly in science subjects. He suggests the following reasons: inadequate time allocated for learning science satisfactorily, inadequate instructional materials, low level and inadequate training of teachers and finally the nature of science curriculum which is highly abstract and seems irrelevant to the learners' immediate environment. These reasons lead to the learner's negative attitude towards science. Among the most widely identified contributing factors towards the poor performance of learners in Physics has been the instructional approaches applied by teachers.

This is because the approach commonly taken by teachers is that of transmission of knowledge from the teacher to the learner that is a teacher behaves as an information provider in most of the teaching time (Brown, 1982); while other approaches make teachers confuse 'teaching Physics' with 'telling Physics' unlike treating Physics as a way of thinking. This makes teachers of Physics to be less innovative in terms of curricula, pedagogy and content (Aron, 1990; Garrido *et al.*, 1990).

There is therefore a need to incorporate teaching strategies that will make learners and teachers to participate actively in the process of knowledge creation and make Physics study a way of thinking rather than a body of knowledge (Gil *et al.*, 1991). Teachers need to be trained to understand Physics as a subject centered on teaching and learning problems that lead to the acquisition of a theoretical foundation of practice. Both Bruner (1957) and Brown (1982) argue that such methods that encourage active knowledge construction lead to better knowledge retention amongst the learner. Some teaching approaches that have been identified to make learning and teaching of science more learner centered and hence thought to be more relevant in teaching Physics include the following: Discussion (class or small group discussions); Project methods; Laboratory experiment approach; Field trip and excursions; Demonstration method; Concept mapping; Constructivist approach (Tobin, 1991); Creativity approach (Jeffrey & Craft, 2001) and ASEI – PDSI approach (Thuo & Gichaaga, 2004). Research has also shown that teachers are responsible for their students' productivity; a teacher should therefore maximize gains and minimize losses during the instructional process. Only a teacher who endeavors to use the best and most effective teaching methods can achieve this and mostly the process-based methods of teaching Physics shown above have been found to be effective in improving learner's productivity (Pierce, 1997). A teacher should be in charge of learning process, directing it, while learners should learn actively under the guidance of the teacher (Cantor, 1946). This study made an attempt in this direction by having the teacher and the learners engage in the set out tasks in a way that learners viewed the teacher as a knowledgeable other and not a knowledge dispenser.

2.4 The Genesis of Creativity Teaching Strategy in Instructional Setups

Galton is thought to have undertaken the first systematic study of creativity 1869; the main focus of these earlier studies on creativity was on the 'genius', but in 1920s onwards the focus shifted to the study and investigation of intelligence which in effect shifted the study of

creativity from philosophical speculations to the empirical investigations. Courses in creativity training were developed as early as 1930s (Crawford, 1954; Mayer, 1983). Parnes and Meadow used creative problem solving approach in their research and found out that creative ability can be improved through training (Parnes & Meadow, 1959). In 1950s, creativity research in education started; Paul Torrance examined classroom conditions that foster or deter creativity and he also developed tests on general creativity which had both the verbal and figural problems and which has been used in many countries (Torrance, 1959). In 1950s creativity studies begun focusing on psychological determinants of individual genius and giftedness; example are Guilford's work in 1950 of examination of intelligence through tests and divergent thinking. There after research has attempted to test and measure creativity and to pin down its characteristics and to foster it through specific teaching approaches (Ryhammer & Brolin, 1999). In 1970, the Purdue Creativity Training Programme for schools was introduced; and in 1986, Okere developed a model of creativity measures in science education (Okere, 1986).

Three main areas of study in creativity have emerged with time; they include the following: Focus on studies on personalities (Einsenman, 1999; Shaw & Ranco, 1994); Focus on cognition (shown by the works of such people as Binet and Henri, Freud, Wallas and Ryhammer). The third area of study is stimulation of creativity shown by the works of such people as Gardner (1993) and Sternberg (1998). Discussion on creativity will always focus on two main aspects of the study, which is producing novel (original) work and appropriate (useful) work. Also it is important to study the cognitive aspects of creativity, which will involve studying how creative people think or what their thought structures is during the creative process (Sternberg & Lubart, 1995). Other researchers have focused on teaching strategies that foster the development of creativity among school pupils (Ndeke, 2003; Okere & Abuto, 2005). This study focused on coming up with modules that can be used to inculcate creativity in learners in the course of the lessons.

2.5 Meaning of Creativity in Science Education

It has not been easy to define creativity; this is because as seen from the above discussion, it touches on many aspects and abilities of human beings. Initially the definition of creativity limited itself on areas of cognition, personality and stimulation in individuals;

but in 1980s, 1990s and up to now, definition mainly focuses on the awareness of its influence on environmental and social contexts (Ryhammer & Brodin, 1999). Creativity also cuts across many areas, for example in scientists, artists and schoolteachers. This obviously generates a wide variety of descriptions. Okere (1996) outlines some of the definitions of creativity relevant to science education and the people behind these definitions. The first definition is that Creativity is a natural mental ability that is inherited; it is a composite of intelligence, motivation and power (Galton, 1869). Secondly, Creativity can be associated with being gifted and also with eminence that is people with high IQ and those who achieve highest eminence are also highly creative (Cox, 1926). The third definition is that Creativity is associated with originality and fluency (Guilford, 1950). Finally Creativity is the ability to be aware of problem, think of possible solutions to the problem and test practicability of such solutions (Torrance, 1959).

Seltzer and Bentley (1999) defines creativity as the application of knowledge and skills in new ways to achieve a value goal and to achieve this, learners must have four key qualities: ability to identify new problems; ability to transfer knowledge from one context to another in order to solve a problem; belief in learning as an incremental process; capacity to focus attention in the pursuit of a goal or set of goals. Craft (2000) talks of little 'c' creativity and defines creativity as 'the ability to be imaginative, going beyond the obvious, being aware of one's own unconventionality and being original in some way', therefore he suggests that creativity is not necessarily linked with a product outcome. Okere (1986) comes up with a scheme that in its attempt to define creativity maps psychological creative abilities on to their corresponding scientific meanings. He gives the psychological meaning of creativity as showing sensitivity to problems, recognizing relationships (e.g. between hypotheses and between seemingly unrelated ideas), showing flexibility in reasoning and having an ability to plan for an investigation. This study was guided by Okere's definition of creativity and based its measures of creativity on his model of creativity measures in science education (Okere, 1996), which was found to be more relevant to the Kenyan school pupils' creativity.

2.6 Assessment of Creativity in Kenyan Education Set-ups

Assessing individual's creativity has been quite complex and problematic; this has been because it involves making comparisons and judgments between individuals, institutions and

systems. Beattie (2000) says that over 200 instruments have been developed for the purpose, but none has been able to measure the concept adequately; her work offers detailed suggestions for the format of creativity assessment tasks and criteria required for judgment, which focus on creative processes, environment and student expression as well as final outcomes. Sefton-Green (2000) discusses the difficulty of assessing learner's improvement and progress and also pupil making personal meanings, expressions, values and attitudes. A creative framework should underpin the aspects of planning, practice and evaluation; it should recognize the interaction between individuals and communities, processes, domains, fields and the characteristics of imagination, fashioning, pursuing purpose, originality and value judgment (Jonassen, 2000). Sinker (2000) discusses the need for development and use of formative creative assessments in which time and space for creativity should be made flexible. Torrance (1966, 1974) developed some psychometric creative tests to test general creativity; they had both the verbal and figural designs. He described four components by which individual's creativity could be assessed and includes the following: fluency, flexibility, elaboration and originality. His tests were mainly on general creativity.

More recently, teachers have preferred to use a variety of means to assess creativity, for example monitoring pupil work, behavior and what they say (Fryer, 1996). Some taxonomies of creativity are difficult to assess in a school situation, teachers therefore prefer to assess pupil performance in relation to their previous performances; something might then be deemed to be original for a particular pupil, otherwise assessing novelty among school pupils will be quite difficult. This is why Fryer (1996) and Craft (2000) suggests that the assessment of school pupils be left in the hands of teachers and less stringent criteria should be used. For example, teachers are advised to use observation and recording of the creative behavior of learners.

The assessment of creative abilities can be split into two categories i.e. the assessment of general creativity and the assessment of scientific creativity. Torrance tests of creativity were mainly concerned with assessment of general creativity. Scientific creativity has been assessed among Kenya secondary school students; Okere (1986) assessed scientific creativity among school pupils by administering open ended design of investigation problem and then analyzing the responses (Okere, 1996). To assess learners' scientific creativity skills, he came up with a mapping scheme which classifies student's responses to scientific problems into their corresponding psychological creative abilities. In this way he hopes that when a learner

is given an open ended design of investigation problems, the responses obtained can be used to assess the scientific creativity of such a learner. The results from his tests showed high consistency in the performance across the problems and also they showed significant correlation between the performance on the design problems and Torrance's tests on verbal creativity. The tests used were developed and validated using Torrance's tests of creative thinking.

Okere and Abuto (2005) assessed the influence of concept mapping teaching strategy on learners' development of scientific creativity; their study involved training teachers in the experimental groups on concept map construction for a period of two weeks. The trained teachers then supervised their students who were working in pairs for three weeks; the control groups did not follow the concept mapping strategy. After the treatment period, the students in the treatment groups did quite well in both the Physics creativity test (PCT) and the concept mapping assessment test than those in the control groups.

2.7 Situation of Creativity in Kenyan Secondary Schools Scene

Very little work has been done locally on creativity; this is evident from the amount of literature available on creativity locally. The available literature indicates low levels of creativity skills amongst science students in Kenya (Okere & Abuto, 2005). The secondary school Physics teaching course books only hope that creativity will be developed out of learner's participation in practical and project work in the course of their studies (ROK, 2002). This study could not obtain any work on development and use of creativity teaching module done within secondary schools in Nakuru district.

Okere (1996) discusses the results of his studies, which he carried out amongst a number of high school (A level) and first year Bachelor of Education (B Ed) and Bachelor of Science (B Sc) students in Kenya in order to observe their performance on scientific creative skill tests. He used an open-ended design of investigation problems to assess the scientific creativity skill of planning of scientific investigation among Kenyan secondary school students. The results showed low performance on the scientific creative skills. This means that there is low creative ability amongst Kenyan secondary school learners. He again carried out the tests among 341 form three students chosen randomly from four secondary schools in Siaya district in 1991. The results showed a low performance level

on creative skills amongst the students; it also showed that scientific creativity is knowledge and content dependent (Okere, 1991). The tests used were developed and validated using Torrance's tests of creative thinking (Okere, 1986).

Ndeke (2003) investigated the level of creativity amongst Form Three Biology students in Nakuru district; she used a sample of 363 students chosen from eight secondary schools in Nakuru district. She found out that the general level of performance in scientific creativity in biology at form three levels was equally low. Her work showed that scientific creativity is gender dependent and that the learning opportunities provided during the lessons are inadequate for effective acquisition of the creative abilities. Okere and Abuto (2005) carried out investigations on the effect of concept mapping teaching strategy on creativity in Physics education. Using Quasi-experimental Solomon Four-group Design, they found that the concept mapping strategy (CMS) had a significant effect on student performance on the creativity skill of recognition of relationships and planning of scientific investigations. Creativity skills were found to be low amongst the secondary school learners.

2.8 The Need for Teaching Creativity in Physics to Kenyan School Learners

Pupils are naturally curious, they wonder about people and the world; Creativity should therefore be inculcated in school going pupils since such pupils enter school with a variety of learning skills acquired through questioning, inquiry, searching, manipulating, experimenting and playing. Such pupils need to touch, to feel, to look closely and also to have a creative encounter. It has also been observed that children's curious tendencies are the basis of creativeness and inventiveness of adults. Children who do a lot manipulation with objects produce the most ideas and the largest number of original ideas. Though teachers and administrators sometimes believe that it is more economical to learn by following strictly laid down procedures, research suggests that many things can be learnt more effectively and economically in creative ways rather than by following fixed systems (Torrance, 1977).

Our country requires creative individuals for its industrial and technological development; this was the reason why the Koech Commission Report recommended the development of creative and innovative minds (ROK, 1999). Parnes and Meadows (1959)

showed that after training individuals through creative problem solving courses, the individuals showed significant change both in quality and quantity of their suggestions. The individuals also faced scientific problems creatively and inventively. They also showed that training makes a person to realize full creative potential; therefore they suggested that we need creative education to deliberately take the creative development of our learners and narrow the gap between an individual's innate creative talent and the lesser creative output.

Teaching creativity promotes talents and innovations in the field of science, technology and arts (Craft, 2000); it defines the most graphic manifestation of the power of imagination and makes the learners to go beyond the obvious and become fluent and innovative (Claxton, 1999). Creativity promotes 'possibility' thinking (Craft, 2000). Torrance (1962) gives some legitimate concerns on the assessments and guidance of the growth of creative abilities: Mental health, creativity is a valuable resource in coping with life's daily stresses and lack of creativity can lead to inflexibility, impoverished imagination, lack of originality and 'mental break' down when responding to a new problem. Creativity will make a school to produce a fully functioning individual especially in talent and skills: for example one's ability to show sensitivity to a problem, recognize relationships when formulating hypotheses, plan for an investigation and being flexible in one's thinking ability. Creativity can lead to acquisition of information and various educational skills i.e. creativity skills have been identified to contribute importantly to the above. Teaching creativity also leads to vocational success especially in scientific and artistic fields among pupils and therefore it should be taught for its contribution towards the quality of our generations societal well - being. Finally creativity makes us to have well-rounded individuals, broad scholars and people with many talents (Vernon, 1970).

2.9 How Should C T S be incorporated into Kenyan Secondary School Physics

Since this study dealt with creativity in a learning situation, the most appropriate definition of creativity will be the one for academic creativity. Academic creativity is defined as a way of thinking about, learning and producing information in school subjects, such as science, mathematics and geography; as such creative thinking may involve abilities such as evaluation (which involves the identification of problems, problems that cannot be checked, and observing relationships to form hypotheses); divergent production (which will involve fluency, flexibility, originality and elaboration) and redefinition of problems to make them

testable. Therefore creative learning should make the learning process natural, healthy and full of curiosity and excitement, it should contrast the learning by authority which requires the students to use thinking skills such as recognition, memory, and logical reasoning (i.e. the abilities most frequently assessed by the traditional tests of intelligence and scholastics aptitudes). Pupils will prefer to learn in creative ways rather than just memorizing information provided by a teacher or a parent, in this way they may learn better or even sometimes faster (Sternberg, 1996).

Since creativity is a life-long essential skill, it should be fostered by the educational system from earlier years (Craft, 1999). This statement emphasizes the role schools may play in promoting creativity qualities in learning experiences. Anning (1994) and Whitaker (1997) give the same views. The National Advisory Council on Creative and Cultural Education (N.A.C.C.C.E) Committee in the U.K. presented a report that had argued for a national strategy in creative and cultural education in 1997. Jeffrey (2000) explains that there is a need for teachers and learners to distinguish between creative teaching and teaching for creativity. To encourage creativity among learners, a teacher should teach creatively (Jeffrey, 2000; Craft, 2001). Many researchers have agreed that creativity can be taught and also can be influenced. Giving challenging activities to children at an early age has been cited as one method of influencing creativity (Edwards, 2000, 2001). High teacher involvement in creative activities is also found to promote creativity among learners to a large extent. Parnes and Meadow (1959) found that the incorporation of creative problem solving courses in the existing subject matter increases the individuals' performance in creative tests.

Okere (1986) noted that low performance on the scientific creative skills is partly due to lack of practice on the skills, he therefore suggested that these skills can be improved by increasing learner participation in the class work through improvisation of apparatus, giving learners more taxing activities, for example preparing instruction manuals in such a way that pupils can think and contribute to the investigation they under take. Learners should be encouraged to criticize their experimental results and give suggestions on how a given experiment can be improved to give more reliable results. He suggests that the educational system should provide: Experimental situations where learners are required to think and come up with experimental set ups for investigating scientific problems; incomplete procedures or faulty procedures and require them to complete the

procedure or order them more logically (Learners should be required to identify what is wrong with the procedures and how to improve on them); experimental set ups that are not scientifically workable and learners required to criticize the experimental set ups or scientific arguments and identify what is wrong with them or why they cannot be checked scientifically.

It is therefore possible to inculcate creative activities in the normal teaching-learning situations with an aim of fostering creativity of learners. This can be done by emphasizing the scientific creativity skills of Sensitivity to problems, recognition of relationships, flexibility in reasoning and planning (Okere, 1986). There are some teaching strategies that have been found to foster creativity. Okere and Abuto (2005) found that concept mapping teaching strategy improved students' performance on the creative abilities of recognition of relationships and planning of scientific investigations in Physics education; while Ndeke (2003) found that gender, knowledge and learning opportunities affect creativity in Biology education. These findings pose a challenge to our school curriculum and school practices; for creativity to be incorporated in our school systems, teacher education programmes should familiarize teachers with the philosophy of creativity in science education. This will enable the teacher to develop the creative potentials of their learners. It will also make teachers to be aware of blocks to creativity and how to overcome such blocks. Since learning opportunities that improve creative abilities are created through classroom interaction designed by teachers, creativity teaching strategies should be included in the curriculum so that teachers can practice and master them (Okere & Abuto, 2005). This study found out that creativity is a skill that can taught to learners by following some teaching strategies. It did this by designing a creativity teaching module meant to inculcate the skills amongst Form Three Physics learners.

2.10 Way forward in the Incorporation of Creativity teaching into Kenyan Schools

Okere (1996) states that the educational system should now focus on instructional strategies that foster learner's thinking abilities and creativity unlike in the past where the emphasis has been on learner knowledge acquisition; schools should be places where learners not only become knowledgeable on subject matter content, but also where they are taught to think and construct knowledge. He further argues that studies and research on educational issues should now focus on getting more effective instructional strategies and not on investigating the processes within them. The teaching of creativity skills is identified as one of the teaching

strategies that can be used to equip learners with process based skills, which will eventually equip them with skills required for their scientific and social development. Good practices in physics teaching should promote critical thinking, problem solving ability and interpretation skills (Aron, 1990). More time should be allocated for teacher preparation and also for preparation of the learning materials (Gallagher, 1994). Okere and Abuto (2005) in their paper entitled 'Creativity in science education and curriculum challenges' presented at Western University College of Science and Technology challenged our school curriculum and school practices in the following way:

'...teacher education programmes should make teachers familiar with the philosophy of creativity for science education...this will help teachers to develop creative potentials of their learners; it will also make teachers to be aware of the blocks to creativity and how to overcome them. The education curriculum objectives should include or reflect creative abilities and suggest how they should be evaluated. Teaching strategies that foster creativity should be included in the curriculum so that teachers can practice and master them...this will enable teachers to create learning opportunities that improves creative abilities among learners... in service training for teachers on meanings and measures of creativity for science education should be adopted' (Okere & Abuto, 2005, pg 11).

Since creativity is the foundation of change and innovation, we all need it; it is therefore the responsibility of education offered to foster creativity in our students. The schools should therefore enhance creativity by integrating it in problem based instruction and also in the resource-based learning. Experimental learning and collaborative learning should also foster it; this will bring changes in the organization of school, the school curriculum and facilities available. Also it may change how teachers and learners interact in schools. The following are quick tips on how a school educational setting can enhance development of Creative abilities in the classroom: providing in class time for individuals and groups to just think and let their ideas marinate; reward creative ideas and products through public recognition even if they are still developing or perhaps may fail; encouraging students to take unique and different approaches in their work and reward any efforts in this direction; allow mistakes and make positive or supportive responses to mistakes; encourage learners to learn from their mistakes; encourage mental flexibility that is taking other view points that learners might not usually take; explore the environment to stimulate curiosity about their world; question

students assumption and guide them to dig deeper and consider their beliefs and that of others to expose students to other ideas. The learning environment should also stop evaluating or judging too soon, there is a time and place when ideas and their constraints need to be considered, but not too soon or the creative learning process will flounder. Also the learning situation should foster co-operation rather than competition; offer choices, encourage dissent and diversity and finally it should regularly provide positive feedback.

The creativity teaching modules developed and used in this study followed closely the above steps, however the already scheduled schooling sessions and daily routine of activities limited the full enactment of some of the module lessons. It is therefore important that teachers should be encouraged to offer curriculum with plenty of opportunities for creative behavior change. They should make assignments that call for original work, independent learning, self initiated projects and experimentation. The curriculum should make creative thinking both legitimate and rewarding; it should also make it easy to provide opportunities for creative learning. A classroom should create the following environment for it to nurture learners' creative ability development: Teach learners to appreciate and be pleased with their creative efforts; respect the unusual questions that learner asks and also the unusual solutions to problems that they give.

Learners are able to see many relationships that others may not be able to see; therefore listening and valuing learners' ideas and considering them as possibilities motivates them to be more creative. Learners should even be let to test their own ideas, and communicating them to others; credit should then be given to such efforts and ideas. Support and encouragement for self initiated learning activities should be availed to make learners to be even more creative. Less stringent learning practices should be adopted since they will afford a learner time for one's own initiative and also create less interference with such efforts. Learners should be allowed to learn, think and discover without threat of immediate evaluation. Constant evaluation especially in practice and initial learning makes learners afraid to use their creative ways to learn. Their honest errors must be accepted as part of the creative processes.

Teachers should also provide a creative relationship with learners; this will encourage creativity in the classroom and at the same time provide adequate guidance to them. The environment should also encourage curiosity, exploration, experimentation, fantasy,

questioning, testing and the development of creative talents. It should also challenge learners to solve problems creatively, use creative expressions and show constructive responses to change and stress. The pupils should be encouraged to use what the school and the environment offers imaginatively in an effort to supplement the school's effort. The schooling environment should not insist on pupils doing things the 'right way'; they should be let to explore other ways of solving the problem or else their urge to try new ways (i.e. creativity) may be killed. They should also not be stressed to be realistic, not to dream, but should be let to dream and fantasize. They should not be compared to others, which will imply conformity with the same standards and expectations, but learners should be assessed on their own progress. All children questions, suggestions and ideas should never be labeled as silly since one key indicator of creativity is curiosity (Torrance, 1977).

2.11 Barriers to Effective Incorporation of Creativity in Kenyan Educational Set-ups

There are some key factors which underpin creative processes and have an impact on the success of teaching for creativity, but also there are some barriers to the development of creativity in traditional educational settings. None are insurmountable, but each should be recognized as a constraint upon learners' realization of full potential of their creative abilities (Kimbell, 2000). Some of such factors include the following: lack of support, understanding, encouragement and effective support and trusting relationship between learners and teachers; teachers lack the willingness or the ability to help promote creativity amongst their learners. Curriculum overloads and lack of sufficient time for curriculum to promote creativity effectively is another factor. This is because schools follow fixed curriculum which do not assess learners' creativity but rather cognitive abilities mainly. Time allocated for various science subjects may not suffice for creative activities thus bringing in the limitations of time. Learners need more flexible time schedules for them to develop creative abilities fully.

The range of technological support materials provided for learners has made little headways in making learners access challenging techniques to foster their own development of creativity; conceptual blocks about creativity are yet to be fully broken. The conceptual blocks amongst learners include perceptual blocks, cultural blocks and environmental blocks. Teachers are yet to appreciate activities that seem child-play but at the end promote creative development amongst learners. The current teachers in the educational system have been trained to teach in the old fashioned teaching methods which do not encompass creativity.

Teachers tend to resist change and resort to their old teaching methods (Vaidya, 1971). These barriers to the effective incorporation of creativity in school curriculum are a challenge to our educational system; at one hand, we need school graduates with creative abilities, but on the other hand the challenges of incorporating Creativity Teaching Strategy are not yet fully addressed. The study would recommend that teachers should incorporate the following conceptual block buster in an attempt to teach creatively. First, teachers should develop a questioning attitude amongst the learners. This would enable such learners to be critical in scientific situations. Secondly, teachers should train learners to spend time and effort on a given task. As the learners turn about a problem, it is likely that they shall come up with several ways of approaching the problem. Thirdly, learners should be trained to listen to other peoples suggestions; such suggestions can help them solve a problem or a task that they are facing. Finally learners should be encouraged to borrow ideas from other disciplines while solving a problem in one area; this will help them think across board (Okere, 1996).

2.12 Learner motivation in Kenyan Educational set-ups

In this study, the main concern is academic motivation amongst secondary school students and how it can be improved. Academic motivation is the psychological process that determines the direction, intensity and persistence of behavior related to learning (Biehler & Snowman, 1997). Motivational factors play an important role in determining the level of achievement at all stages of academic study. A motivated student will have an inner state that energizes channels and maintains behavior and directs it to some desired need or goal (De Cecco & Crawford, 1988). Broadly, motivation can be either intrinsic or extrinsic (Good & Brophy, 1995). A teacher should therefore consider both in his/her teaching approach. A teacher should use classroom practices that arouse students' interests and attention, raise their expectancy of success in their academic work and give them incentives and rewards that they value. The subject matter taught, should be relevant to the needs of learners (Burden, 1995).

The concept of creativity has been recognized as being multifaceted and there are some factors generally accepted as essential to the development of creativity. One of such factor has been motivation which has been found to be a strong drive of creativity (Sternberg & Lubart, 1996). Motivation is also a factor that is more easily influenced than the other contributing factors. There are six strategies that may be used to influence intrinsic

motivation: challenge, freedom, resources, workgroup features, supervisory encouragements and organizational support. These factors are parallel to those found in the Kellers (1984) ARCS model where freedom corresponds to choice and control etc (Lubart, 2000). Many researchers and scholars have underscored the need of teachers to consider motivational factors in their teaching. Biehler and Snowman (1997) indicated ways in which Maslow's Motivation Theory could be applied in a teaching/learning situation and they pointed out that a teacher should: arrange classroom conditions to make students feel comfortable when working in groups and when asking questions; clarify general and specific objectives of the topic or lesson; encourage the learners to achieve; set attainable goals for learners and guide them there and make the study interesting by giving opportunities for activities, investigation and socialization.

In the teaching learning situation, educationists have come up with a theoretical model for explaining the components of motivation to learn (Keller, 1984; Malone, 1981). In this model motivation consists of four different dimensions as follows: Fantasy: Learning situation in which there is inclusion of subject matter that will trigger learner's imagination and emotional involvement. This makes a learner to enjoy the subject matter. Control of learning: Refers to a situation where a learner finds subject matter meaningful, has self efficacy, self regulation and the student is able to determine mastery or the coverage of contents. Challenge: A learner interacts with content in a learning situation that is neither too easy nor too difficult; a learner experiences more of success than failure at performance of tasks. Curiosity: Learners should find subject matter not too familiar nor too unfamiliar, incongruous or complex; learners would then feel at ease and seek to learn new valuable knowledge. Keller (1984) redefined the four dimensions of motivation to learn and referred to them as Attention (A), Relevance (R), Confidence (C), and Satisfaction (S) respectively; this is Keller's ARCS model for understanding motivation to learn. Burden (1995) elaborates clearly on each of the four components of motivation to learn in Keller's (1984) ARCS model and proposed how teachers can use it to plan for enhancement of motivation to learn academic contents.

Both Burden (1995) and Horn (1995) describe the four components of the model for understanding motivation to learn academic subject and proposes how teachers can use it to enhance students motivation. The table below outlines the above models, giving their descriptions and applications to mathematics learning (Githua, 2002):

Table 3: Model of Understanding Motivation to Learn Academic Content as Proposed by Malone, Keller and Burden and its Applications to Mathematics Learning

MALONE, 1981	KELLER, 1984	BURDEN, 1995	DESCRIPTION	APPLICATION TO MATHEMATICS LEARNING.
Fantasy	Attention	Interest	Extend to which learner's interest is aroused, responds and attends to subject matters or impinging stimuli.	Learner enjoys, loves, is motivated, not frustrated, does not find mathematics dull or boring.
Control	Relevance	Relevance	Extent to which learners perceive content of subject matter to be significant and valuable to them	- Aspiration for continued study after high school. - Sure of studying mathematics after high school. - Finds mathematics meaningful. - Finds mathematics related to life experience, needs and goal. - Likes career that require mathematics.
Challenge	Confidence	Perceived probability of Success.	Learners perceived likelihood of success through personal control of their behaviour.	- Learners work independently. - Applies mathematics to life situations. - Experiences success in mathematics. - Gets satisfactorily high score in mathematics
Curiosity	Satisfaction	Satisfaction	Learners' psychological equilibration due to experience of extrinsic reward and realization of intrinsic growth.	- Finds mathematics rewarding. - Feels at ease in mathematics class - Satisfied with learning, teaching and participation in mathematics lessons.

Source: Githua (2002; pg 51)

Learner's interest is one of the dimensions of motivation, it makes a learner to focus selectively and readily respond to an impinging stimulus which is perceived to be significant.

It is closely related to attention. Teachers can enhance it by use of analogies, humor, arousal value of suspension, curiosity, fantasy, adventurous etcetera. Relevance to academic subject matter is the extent to which the subject matter is viewed as being relevant, significant and valuable. Teachers can enhance it by linking new content to the previous one, stressing the usefulness of the subject to learners and explaining its career opportunities clearly. Perceived probability of success in a subject refers to the perceived likelihood of success, confidence or belief in one's success. It can be enhanced by allowing students to choose optional subject tasks, de-emphasizing social comparisons, communicating clear expectations, sequences and standard of performances. Finally, learner's satisfaction will involve teacher's provision of extrinsic rewards and feedbacks on performance as well as learners realization of intrinsic needs. This can be enhanced further by constructive criticism, rewards, praises, grades, corrections and positive comments.

Burden (1995) further argue that the enhancement of the four dimensions of motivation to learn academic subject matters enhances learners attitude towards learning, enjoyment and retention of the learnt subject matter. This study used the above suggestions to test for motivation in both the control and tested groups; the main dimension of motivation focused on in the study was interest. The study therefore tested whether the incorporation of creativity teaching strategy in the topic 'energy' amongst form three Physics students in Nakuru District had a significant influence on their motivation. The study did this by using a Physics self assessment questionnaire (PSAQ) that was developed based on the above model of understanding motivation to learn academic content. The above model was chosen because the correlation in learners' performance in Physics and mathematics is usually high. The PSAQ questionnaires accompanied both pre-test and post-test instruments in the experimental and the control groups. In the PSAQ questionnaire, for each one of the dimensions of motivation above, five questions were offered and therefore the PSAQ questionnaire had a total of twenty Likert type questions; a learner answered them by selecting a choice from the Likert scale.

The PSAQ questionnaire is outlined in appendix B3. It has four sections: section I contains questions related to interest of the learners to learn the topic 'energy'; Section II contains questions related to the relevance of the topic to the learner; section III contains questions related to the learner's perceived probability of success emanating from the topic and section IV of the questionnaire relates to the learners perceived satisfaction after learning the topic.

The influence of creativity on learner's motivation was assessed by comparing the level of learner motivation before learning the topic 'energy' and after learning the topic 'energy' following the creativity teaching strategy. During data analysis, the four dimensions were assessed differently and the analysis done independently. This was because creativity teaching approach could have influenced some dimensions and not others. The study would then suggest which one of the dimensions of motivation was mostly influenced by the Creativity Teaching Strategy.

2.13 Theoretical Framework

Galton is believed to have undertaken the first systematic study of creativity in 1869; the main focus in these earlier studies on creativity was on 'genius' (Ryhammer & Brolin, 1999). But from 1920s on wards, the focus of creativity shifted from 'genius' or 'giftedness' to the study and investigation of intelligence using empirical investigation (Ryhammer & Brolin, 1999). By 1950s the focus shifted to investigation of divergent thinking as evident in Guilford's work. Therefore many tests have been prepared alongside to test and measure creativity in individuals. A creative assessment framework should underpin the aspects of planning, practice and evaluation. Torrance (1966, 1974) developed psychometric creative tests in which he said an individual's creativity could be assessed by observing the individual's fluency, flexibility, elaboration and originality. Many other researchers and scholars have come up with tasks and measures for creativity, but most of them are not applicable in assessing creativity among students in formal schooling situations. Parnes and Meadow (1959) carried out a series of studies which showed that the incorporation of creativity tasks in existing subject matters in schools increases the subjects' performance in creative tests. They echoed what Guilford had said that 'like most behaviors creative ability represents to some extent many learned skills'; therefore through learning, one can extend the skills within any limitations and a considerable part of creative behavior is learned (Guilford, 1952).

This study used modified creativity modules and based its assessment of creativity on Okere's model of creativity measures in science education in which the psychological creative abilities that have relevance to science education have been redefined and an appropriate problem for measuring such abilities developed. The student's responses to a scientific problem could then be classified into their corresponding psychological creative abilities

(Okere, 1986). Okere's model of mapping psychological definitions of creativity onto their scientific meaning in science education is shown in the figure below:

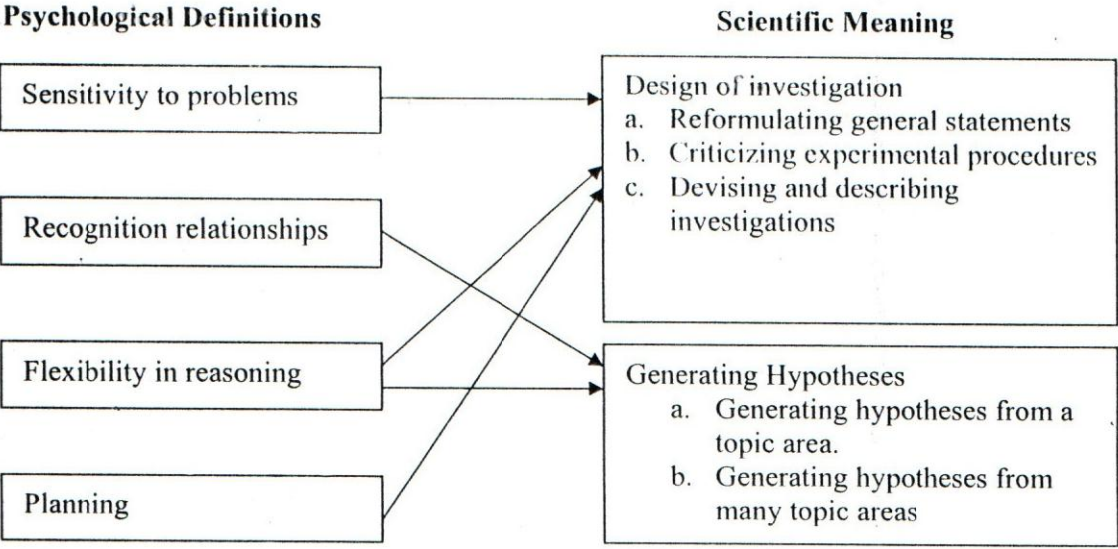


Figure 1: The Mapping of Psychological Definitions of Creativity onto Scientific Meanings (Okere, 1996, Pg 46)

The model above tells us that by observing an individual's responses to scientific problem one can assess the psychological aspects of the individual's creativity: the psychological creativity aspect of sensitivity towards a scientific problem can be assessed best by offering the individual a scientific situation that require the individual to either reformulate a general statement so that it is testable or criticize an experimental procedure. It can also be tested by requiring such an individual to device and describe an investigation; the creativity aspect of recognizing relationship can be assessed by requiring an individual to either generate hypotheses from one topic area or generate hypotheses from many topic areas; the creativity aspect of flexibility in reasoning can be assessed scientifically by requiring an individual to design an investigation or generate hypotheses; the number of designs of investigation and hypotheses that an individual comes up with is an indicator of the individuals' flexibility in reasoning. Finally, the psychological creativity aspect of planning can scientifically be assessed by requiring an individual to design an investigation and criticize such a design by giving the sources of error that will affect the investigation and also give the necessary control variables. The model also implies that the psychological creative ability of planning may be assessed by problems on design of investigations where the learners' scientific ability of devising and describing investigations is assessed, while psychological creative ability of

sensitivity can be assessed by the learners' ability to criticize their experimental procedures by giving the sources of errors in their experimental situations. Also a scientific problem on creativity will require the application of several psychological abilities. Since the study was interested in two of the above aspects only, i.e. sensitivity and planning, scientific aspect of designing an investigation was involved. Learners were given situations that required them to outline an experimental procedure they would use to solve a scientific problem. They would then criticize their procedures by giving sources of error and control variables. A correct design of investigation having relevant control variables will mean that the learner exhibit the psychological aspect of sensitivity while correct sources of error mentioned meant that the individual exhibited the psychological creativity aspect of planning. Schematically, the interaction of the various variables in the study could be illustrated as shown in the figure below:

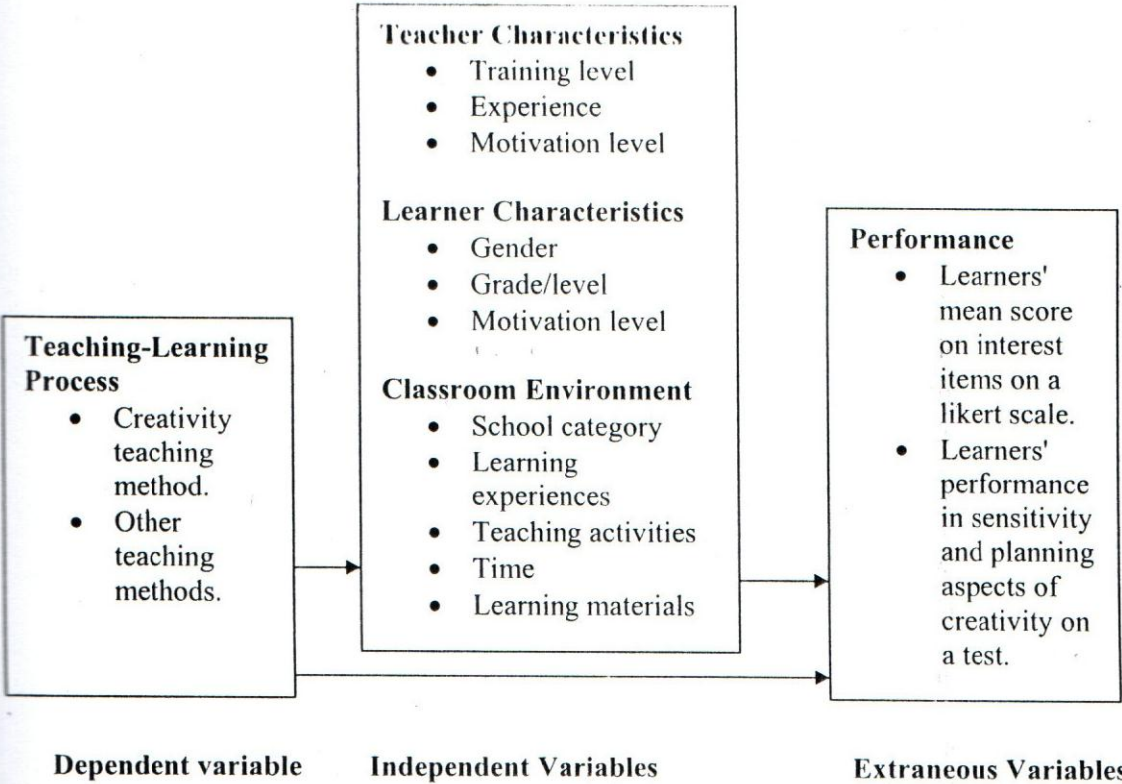


Figure 2: A Schematic Representation of the Interaction of Various Variables in the Study. Source: modified from Githae, (2004, pp34)

The figure tells us that the teaching learning process is affected by teacher, learner and classroom environment characteristics which include teachers' level of training, experience and motivational level, while learners' characteristics include gender, grade/level and

motivational level. Classroom environment will include such factors as school category, teaching-learning experiences, availability of teaching/learning resources and activities, learning materials and time allocated for learning science. Such characteristics would either promote or inhibit the acquisition of creative skills and motivation. By holding the extraneous variables constant and building motivational variable into the study, the influence of creativity teaching strategy on development of creative skills and motivation among learners could be assessed by varying the independent variables. Having one group of learners taught Physics following the creativity teaching strategy while another group continues to learn following the regular method will do this.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

In this chapter, the research design, the population targeted and the sampling procedures are outlined. The chapter also describes the sample size, instrumentation, data collection and data analysis procedure. Finally it presents the data analysis summary table.

3.2 Research Design

The study adopted quasi experimental Solomon three group design which was considered sufficiently robust and appropriate for experimental studies (Gal *et al.*, 1996; Ogunniyi, 1992). Table 4 below represents the scheme of quasi experimental Solomon three group design:

Table 4: Representation of Quasi experimental Solomon three Group Design

Group	Pre-test	Treatment	Post-test
Experimental (E)	O ₁	X	O ₂
Control group (C ₁)	O ₃	-	O ₄
Control group (C ₂)	-	X	O ₅

Source: Koul (1984)

Key:

X - Treatment

- - No treatment

O₁ - Pre-test experimental group scores

O₂ - Post-test experimental group scores

O₃ - Pre-test true control group scores

O₄ - Post-test true control group scores

O₅ - Post-test second control group scores

Quasi-experimental design was favoured because the study intended to observe the influence of a teaching strategy inside a classroom. One way of doing this would be through

experimenting with the strategy (inside a classroom) without affecting the already formed classroom setting following quasi experimental Solomon three group design. This would control for the reactive effect since the subjects would be less aware of their participation in an experimental study (Cook & Campbell, 1979). The differences between the control and the experimental group after treatment in the study would tell us whether the method had some influences on the learners' performances in the tested creative abilities and on motivation. The use of pre-test, post-test method was also favoured since it gives the difference between the experimental and control groups in a more simplified way, which is easier to interpret. Other designs such as Solomon four group designs could have been used but they would be more involving in terms of samples required and time and their data analysis and interpretation would be relatively more complicated. This was why the study chose to use Solomon three group design.

Non- randomized control group pre test-post test design could not be used due to the problem of specific selection, which could have led to selection differences since the method does not take care of the interaction between selection and treatment. Solomon three-group design addressed this problem by introducing a second control group (C_2), which was not pre tested. Contamination problem was addressed by having control and treatment groups in different schools, which were far apart. The type of research design used though had one limiting factor which could have affected the generalisation of results which was the non-equivalence of samples. Obtaining equivalent samples was a problem since schools admit learners who are not at the same level in their academic achievement. Also the equivalence of groups was compromised by lack of randomisation.

3.3 Location of the Study

The study was carried out among form three Physics students in co- education day secondary schools sampled in Bahati/Mbogo-ini divisions of Nakuru district. The divisions had more than twenty secondary schools out of which ten schools offered Physics up to Form Four level and had Physics classes with at least thirty students. Piloting was conducted in district co-education day schools within Nakuru municipality. Form Three Physics students were chosen to participate in the study since from the pilot study report they were found to be more stable and established in the secondary school curriculum, and therefore their responses could be more reliable. Also much of the content of the topic 'Energy' is covered at this level. The

topic on 'energy' was chosen as it was found to cut across all the science subjects and also it is taught at all levels as evident from the secondary school physics syllabus. The topic also offers a set of varying daily experiences to the learners which they can easily visualize in a classroom situation. An effort was also made to teach the topic as part of normal school work unlike treating it as a distinct content and pull it out of the syllabus and teach it distinctly; learners were therefore expected to view it as a programmed normal school lesson.

3.4 Target and Accessible Population

The study targeted Form three Physics students in co- education day secondary schools in Nakuru District. This was because the topic 'energy' in the Physics syllabus is usually covered at this level. Also the Form Three students were found to be more stable and focused than the rest in lower forms in secondary school curriculum. The study targeted district co-education day schools in order to avoid both academic and gender disparity. Physics teachers falling in the experimental and control group two (C₂) were also targeted (for the induction course).

3.5 Sampling Procedures and the Sample Size

Due to the fact that the researcher could not be allowed to reconstitute the classes in the course of the study, a reasonable and representative sample of the population had to be obtained and used. In General, the sample size would be determined by the number of variables in the study, type of the research design, methods of data analysis and the size of accessible population (Ary *et al.*, 1972; Borg, 1987). Gal *et al.* (1996) and Ogunniyi (1992) suggested that a minimum sample size of 30 subjects is sufficient for comparison purposes in experimental studies. The sampled classes yielded a student population of 114 which was the total number of subjects who participated in the study. The sample size per class was justifiable because it was made up of subjects who had chosen Physics subject on their own volition and therefore represented a homogeneous sample in terms of learners' interest in Physics. They were therefore expected to be very close to each other in terms of performance and level of motivation.

The study obtained a sample of schools from co-education day secondary schools within Bahati/Mbogo-ini divisions, Nakuru District. The schools involved in the sampling process

were identified through Random assignment. The divisions had more than 20 secondary schools out of which at least 10 co-education day secondary schools offered Physics up to the level of form four. This was the sampling frame. The three schools involved in the study were identified from the ten schools through simple randomisation. The schools were assigned numbers 01 to 10 and balloting used to pick the schools from the sampling frame. Simple randomisation was again used to put the three schools into the experimental (E) group, control group 1 (C₁) and control group 2 (C₂). In the case where the school carrying C₂ had more than one Form Three streams taking Physics, simple randomisation sampling technique was again used to identify a particular class out of the streams to participate in the study. Table 5 below shows the summary of the sample sizes obtained in the various groups.

Table 5: Sample Size in Various Groups:

Group	Sample Size
Experimental Group (E)	31
Control Group (C1)	41
Control Group (C2)	42
Total Sample Size	114

3.6 Instrumentation

The instruments used in the study are outlined in appendices A, B-1, B-2 and B-3. An instrument must measure exactly and precisely what it is out to measure. According to Gronlund *et al.* (1988), an instrument will produce good results if it has been validated by at least 5-experts. He recommends a reliability coefficient of not less than 0.7. In this study, the instruments were validated using Kuder-Richardson formula 21 (K-R-21) which was found to be appropriate because it can determine the reliability of an instrument using a single administration (Kathuri & Palls, 1993). The study used four types of instruments: three instruments were used for data collection while the fourth one was the instructional modules. The instructional modules covered the content under the Form Three Physics topic 'energy' which took a period of three weeks to be taught. The data collection instrument included a pre -test, a post-test and the PSAQ questionnaire. These instruments were found to be better in obtaining the data concerning the study because previous studies have shown that a learner's creative ability can be influenced through training (Okere, 1986; Okere & Abuto,

2005). Also the studies have shown that learners exhibit their creative skills through their responses in a situation that require them to solve a problem (Okere, 1986). Therefore when learner's creative skills are assessed before and after treatment, the difference can tell us whether the treatment had a significant influence on the learner's creative skills. The pre-test and post- test applied consisted of questions that required learners to think across a broad science area while the PSAQ instruments required learners to state their feelings or levels of interest in Physics at that particular time. The learner's ability to show creative skills of sensitivity and planning in a scientific investigation was assessed keenly. The modules and tests were prepared based on Okere's model of creativity measures in science education (Okere, 1996). Sub-sections 3.6.1, 3.6.2 and 3.6.3 describe each one of these instruments in details giving their brief summary and the nature of questions that they contained.

3.6.1 Pre-test and Post-test Data Collecting Instruments

These instruments consisted of open ended questions that the researcher felt were at the same level of difficulty to which the piloting attested and the learners were allowed a maximum period of 50-minutes to respond to them. The instruments aimed at measuring the change in the creativity skills possessed by the learners before and after treatment. They were to do this by assessing learner's creative skills in the following aspects:

- a) Sensitivity to problems: a learner who could criticize an experimental procedure by giving the sources of error that might have affected the results exhibited this aspect of creativity.
- b) Planning: a learner who could devise, design and describe an investigation exhibited this aspect of creativity. Such a learner would also criticize the experiment procedures he/she comes up with (Okere, 1986).

The pre-test and post-test instruments are outlined in appendices B-1 and B-2 respectively. This study chose to use the pre-test and post-test instruments since they have been found to be more effective in collecting data in this type of research (Okere & Abuto, 2005). Such instruments adequately measure the respondent's creative skills possessed before and developed after the treatment by comparing their responses from the tests. They also give a clear ground of making comparison. The study favoured test administration because secondary school learners are used to answering questions in the test form during school assessment process and the learners are therefore used to questions in a test form. The

learners may not be comfortable with the other forms of assessment for example questionnaires and interviews since they may not have been exposed to them adequately.

Both the pre-test and post-test instruments consisted of a single question which the learners were to answer by reacting to a set of six sub questions arranged in a systematic way. In the pre-test instrument, the learners were required to find out if the amount of work done on a spring by a falling object depends on the type of the material from which the spring is made. In the first sub question, the learners were expected to state the things (apparatus) one would use to carry out such an investigation. Here the learner was expected to give both the ordinary apparatus found in the laboratory and the other less seemingly obvious apparatus. The second and the third sub question required the learner to explain what should be measured and how the measuring should be done. In part four the learner was required to explain how the problem would be solved; here mathematical expressions and verbal explanations were expected to feature. Lastly, part five and six required a learner to criticise his/her own experimental set up by naming the control variables and the sources of errors; correct sources of errors named would mean that the student has the creative aspect of sensitivity towards a scientific problem, while naming the correct control variable would mean that the learner will at least be able to carry out a fair experiment and therefore the student possesses the creative aspect of planning.

The task set in the test paper was estimated to be completed within 50 minutes as for an average student each sub question would roughly take six to eight minutes to be answered. The pilot report showed that the time allocated was sufficient since most of the respondents did answer all the questions within the set time limit. The instruments were to measure change and therefore the pre-test instrument was administered to the control and experimental groups after which the experimental group E and control group C₂ were treated, while the true control group C₁ given no treatment. After the three weeks treatment period, the post test was administered to all the groups and comparisons made. The change in the respondents' creative aspect of sensitivity was assessed through the comparison of the average scores in the sources of error given both in the pre and post tests for the true control and experimental groups. The same comparison was made for creative aspect of planning but in this case the average scores in the number of control variables given in the two groups were considered. Sensitivity to problem had been defined by Torrance and Guildford as the ability to be aware of problems and to think of possible solutions to the identified problem (Guildford, 1950;

Torrance, 1959). Planning for a scientific investigation will involve formulating general statements to make them testable, criticize given experimental procedures, suggest improvement to the procedures, devise and describe sequences of the investigations (Parnes, 1963; Hudson, 1967)

3.6.2 The PSAQ Questionnaire

The PSAQ questionnaire contained a set of questions that aimed at finding out the interest and motivation levels of learners before and after treatment in the topic 'energy'; it contained some twenty (20) likert type questions in which learners were expected to make a choice from the five given choices, depending on their level of agreement with the choice. The questionnaire contained positive questions only as they have been found to be easy to understand, easy to respond to and easy to score (Mugenda & Mugenda, 1999). The questions, constructed on a five point likert scale were to assess students' motivation before and after treatment. The information sought by the PSAQ was based on the following dimensions of motivation as indicated by Githua (2002): interest, relevance, perceived probability of success in physics and satisfaction in learning physics. The question items were developed and modified from those ones of Githua (2002) that concerned motivation in learning mathematics. They were also pilot tested alongside the pre-test and post- test items and their reliability obtained using the coefficient alpha method (Ebel – Frisbie, 1991) which was found to be the suitable formula since the test items were constructed on a five points likert scale.

The formula is as shown below:

$$\alpha = \frac{k}{k-1} \left[1 - \frac{\sum s^2_i}{sx^2} \right]$$

Where k = number of items in the test

sx^2 = total variance of the total test

$\sum s^2_i$ = sum of the variance of the individual items

The coefficient α obtained was 0.875 (from the computer SPSS data analysis package). This coefficient showed that the instruments were reliable since the value of 0.875 was above the minimum acceptable level of 0.7 for non exploratory studies (Cook, 1976).

3.6.3 The Creativity Instructional Modules

Okere (1986) noted that the low performance on the scientific creative skills is partly due to lack of practice on these skills; he suggested that performance in such skills can be improved through improvisation of equipments, which will make learner participation in classroom experiments to be increased. He also suggested that the learner instruction manuals be written in such a way that the pupils are required to think and contribute to the investigation they are performing, for example learners should be encouraged to criticize their experimental results and give suggestions on how a given experiment can be improved to give more reliable results. The creativity teaching modules used in this study were prepared based on Okere's model of creativity measures in science education (Okere, 1986). The modules aimed at encouraging learners to think creatively by providing them with:

- a) Experimental situations where they are required to think and come up with experimental set ups for the investigations of scientific problems; for example learners may be provided with apparatus and instructional manuals and then are required to outline how to proceed with the investigation process, then criticize their apparatus and procedures and show sensitivity towards the sources of error by explaining some of them. This will improve their psychological aspect of planning and sensitivity to scientific problems;
- b) A day-to-day experiences that have a scientific bearing which required them to assess the situation critically. For example, observing objects falling and suggesting where force possessed by such bodies as they fall can be applied, discussing such critical situation such as waking up one day and find there is no sunlight. This will improve learners' creativity skill of sensitivity to scientific problems. The modules also hoped to give learners the experience on how to deal with scientific situations creatively. Such experiences would be useful since they may enable learners to think logically and critically when faced with novel situations (Parnes & Meadow, 1959). The modules were expected to promote creativity amongst Physics learners by: giving learners sufficient time to think on the best way to carry out an investigations; giving learners challenging tasks that require them to think and apply the products of their thinking in a problem solving situations and within a specified period of time. They also require learners to apply higher cognitive skills such as analysis, synthesis and application.

In the process of curriculum reforms, the modules developed fall under the area of curriculum renewal. An existing topic such as the one chosen in the study on 'energy' is modified slightly so that it can be taught following a new set of instructional strategies. It is important to note that all the initiatives for curriculum reforms in Kenya come from the ministry of education and then are communicated to KIE which deals with the development of curriculum and teaching materials for various subjects. Therefore as the modules were being prepared, greater care was taken to ensure that apart from the incorporation of the creative activities, all the other aspects of the topic coverage remained the same. The study developed its own set of modules to use in the research mainly because the use of such developed teaching modules will be more effective unlike the borrowed ones whose foundation may not be very familiar to the user. The study would make a suggestion that in future the development of teaching materials and or changes in the curriculum should involve as many teachers as possible, especially in the inception and in the piloting stages. The study hopes that the instructional modules did achieve their intended goal.

3.6.4 Validity of Data Collecting Instruments

Before the instruments were used, they underwent a validation process. This involved first subjecting them to discussion from secondary school Physics teachers who assessed their suitability. The instruments were then forwarded to the Department of Curriculum, Instructions & Education Management at Egerton University, where they were subjected to discussions with the lecturers in the areas of measurement and evaluation who helped in assessing their suitability (i.e. their content and construct validity) and criticizing them as well. Finally, the agreed upon tests and modules were piloted in three secondary schools which were not involved in the study later on. This was to prevent such schools from contaminating the study samples and results obtained in the course of the study. The piloting of instruments aimed at subjecting them to real classroom situation in order to check for their suitability, reliability and also to further solicit relevant modifications and get feedback on their quality. The data collected from the pilot study was used to compute the reliability of the instruments. During the validating process, both the concurrent and content validities were checked and a table of specification drawn to help assess them. The items included in the tests were found to be at the appropriate difficult level for the Form Three pupils and were therefore within their ability. Usually the term validity refers to the extent to which a test instrument does the job for which it was designed; the validity of the study instruments

was evident from the pilot reports since the instruments were found to be able to elicit the expected types of responses from the students which were useful for the comparison purposes. From the pilot reports, the study was able to establish the reliability of the instruments and in this case reliability defined as the extent to which a test is consistent in giving the same results any time it is applied.

3.6.5 Reliability of the Data Collecting Instruments

The study established the reliability of the pre-test and post-test instruments by applying the K-R-21 formula on the data obtained from both the trial tests and the pilot study. To ensure that the two tests were at the same level of difficult, they were administered to two groups in the same classroom within the same school and the data obtained correlated using the Pearsons' Moments Correlation formula shown below.

$$r_{xy} = \frac{N\sum(xy) - \sum x \sum y}{[N\sum x^2 - (\sum x)^2][N\sum y^2 - (\sum y)^2]}$$

Where x - Scores for pre test instrument

y - Scores for the post test instrument

r_{xy} - Pearsons Moment Correlation value

The test instruments were found to have a correlation coefficient of 0.8 and a reliability coefficient of 0.78 in the pilot study meaning that they could give reliable data which could then be generalized within the significance level of the study. The reliability coefficient of the instruments in the study was established by applying the K- R21 formula on the data obtained in the piloting stage. This formula was chosen because it is simple to understand and to apply in calculations. The K-R21 formula is as shown below:

$$r_{k-R21} = \frac{ks^2 - m(k-m)}{(k-1)s^2}$$

Where r_{k-R21} = the K-R21 reliability coefficient

K = total number of stages where marks were awarded in the test.

M = means of the set of tests

S = standard deviations of the tests

From the pilot study results the r_{k-R21} value was found to be 0.78. This was an accepted value since it was above the accepted minimum value of 0.7 in such a study.

3.7 Data Collection Procedures

Data collection procedures started after the researcher obtained an introductory letter from the Graduate School, Egerton University which helped seek for permission to carry out study in different areas and institutions. After obtaining the Research Permit from the Ministry of Higher Education and seeking for permission from the local DEO's office and various head teachers, the researcher administered pre tests to the sampled Physics classes in the two groups to be pre tested (that is control group C_1 and experimental group E). The pre-test consisted of the open-ended design of investigation problem together with the PSAQ questionnaire. Learners were required to design and describe an experiment to be used for a scientific investigation and criticize the mentioned experimental set-up in terms of control variables and sources of errors. The students responded to the tests within 50 minutes and the researcher with the help of the identified Physics teacher collected the answered scripts. The experimental group E and control group (C_2) then received instruction following the creativity teaching modules prepared for the topic 'energy' as outlined in the learner's course book (i.e. Form three Physics syllabus, Section on 'Energy') the reference book being Longhorn secondary Physics Book Three. The control group (C_1) continued to receive instruction through the usual teaching procedure as advocated for in the syllabus and in the teacher guides.

After the Creativity Teaching Strategy instructional period ended, all the groups i.e. control group C_1 , control group C_2 and the experimental group E, sat for a post test; and just like in the pre-test, the post-test was also an open-ended design of investigation problem intended to achieve the same objectives. It presented a scientific problem that was different from the one in the pre-test, but deemed to be at the same level of difficulty. The post-test was also accompanied by the same PSAQ questionnaire carrying the same information and details. Learners were continuously encouraged to respond to the tests and to the questionnaires to avoid a situation where some research participants would not respond to the entire test or would receive it and not respond to it at all. The data obtained was then organized, coded and finally analysed using both chi-square and inferential statistics.

3.8 Preparations for the Implementation of Creativity Teaching Strategy

Letters to seek permission for the study to take place in schools selected were presented to various schools heads with the permission from the local DEO'S office. The head teachers allowed the research to proceed in their schools though reluctantly since most of them viewed the research process as a disruption in the smooth flow of the school programmes; in one case, the physics teacher was allowed to conduct the modules teaching on Saturdays and any other time outside the school timetable. The researcher had no problems with such an arrangement as long as the modules and the instruments were adhered to strictly.

3.8.1 Teacher Induction for the Modules Teaching

Once the head teachers gave a go ahead for the study, the researcher met the respective teacher in each group. In both the experimental and second control group (C₂), the responsible teachers were inducted on how to teach the topic following the modules. On the first day, the teacher in the experimental group (E) was inducted. The induction process mainly involved drawing a parallel between the regular teaching methods and the creativity teaching approach. In each one of the twelve lessons in the creative teaching modules, the researcher took the teacher through them, describing what was expected of the teacher, the learners and the school learning environment. Also the researcher explained clearly the purpose of the research undertaking to the teacher. Once satisfied that the teacher had understood what was required of him, dates for pre-test administration, module teaching and post-test were set. The pre test was set to be administered on 15th Sept 2007, while the module teaching was to begin on 17th Sept 2007 then proceed for three weeks. It was scheduled to end by 6th Oct 2007. Post-test would be administered shortly after the end of the module teaching i.e. on 6th Oct 2007. The same induction process was repeated with the physics teacher in the second control group (C₂). The teacher in control group C₂ also approved the same dates for the module teaching and the post test. The students in the control group C₂ would not respond to the pre-test instrument but would start with the modules, the teacher in the control group (C₁) was not inducted on the creativity instructional strategy but was required to teach the topic on 'energy' following her usual instructional process.

3.8.2 Teaching and Tests Material Preparation

After the teacher induction processes, the materials for the research were then prepared. The materials were prepared based on the number of students in each group. The largest group had forty two students, while the smallest had thirty one. Sufficient copies of the creativity instructional modules were prepared, a copy for each student in the experimental (E) and second control group (C₂). Pre test question items together with a copy of the PSAQ questionnaire were also prepared sufficient for the control group (C₁) and the experimental group (E). Post-test question items together with the same PSAQ questionnaire were also prepared sufficient for the students in the three groups. For the section on 'energy' under the topic 'work, power and energy' in Form Three physics syllabus, the content was divided into twelve sections; each section being equivalent to a module and an appropriate teaching module developed to teach it under the CTS. The topic was enriched by incorporating what the learners had already studied earlier in Form one and two and also what they were yet to learn in Form Four. Earlier on the students had studied about energy under the topics such as 'Force', while at a higher level (form four) they shall study it under the topic 'Quantity of heat' (Longhorn Secondary Physics, Book 2, 3, and 4).

The prepared modules were finally discussed with the secondary school physics teachers and the study supervisors. Once found to be satisfactorily polished, they were prepared for use. The teacher in the experimental group was allocated 33 copies of the modules to ensure that each of the research participants received a copy of the modules. The teacher was also allocated an equal number of pre test instruments. All the teachers in the other research groups received materials proportionally to the number of research participants in their groups. The materials supplied were to enable the teachers administer a pre test and afterwards teach the topic on 'energy' following the CTS. Once sufficient pretest and the materials for teaching modules were ready, then the CTS commenced.

3.8.3 Pre Test Administration

The pre-test instrument (coded 'marble') accompanied by the PSAQ questionnaire was delivered to the responsible physics teacher in the experimental group by the researcher few minutes to the start of the schools' 4 to 5 o'clock preps period when the research participants were to respond to the instruments. The following day the same procedure was repeated with

the control group (C_1). There was no fear of contamination as the two schools were at least twenty kilometres apart and therefore not likely that the learners could meet. The learners were allowed a maximum time of 50 minutes to response to the instrument. The researcher remained keen to ensure that all the instruments handed out to the research participants were collected back after the lapse of the indicated time. However, the researcher remained at the background and allowed the interaction to be mainly between the responsible teacher and the learners. On average, 98% of the issued test instruments were collected back after the students' responded to them.

3.8.4 The Instructional Modules for the CTS

After the pretest administration, the creativity instructional strategy commenced. The researcher forwarded the instructional modules to the teacher in the experimental group (E) and in the second control group (C_2) so as to enable them to start teaching the physics topic on 'energy' following them. Once more again the researcher reminded the teachers about the general overview and what was expected of them in the Creativity Teaching Strategy. The teachers embarked on the instructional strategy teaching on 17th September 2007, and carried it out for three weeks. However, there were some factors that affected the study and brought changes in the timing and the completion of the instructional process. The factors given by teachers ranged from fluctuations in school term activities to learners being sent away from school due to school fees problems. Whenever a quarter of the class was absent, the teacher felt a need to hold the modules teaching until a time when most of the students would have reported back in school. During this time, the teacher would continue teaching other content not covered under the modules. The first five lessons of the modules were considered core to the study since they were intended to inculcate the skill of planning which was core to the development of the other creative skills in a learner. In these lessons the learner mainly dwelt on the area of isolating and identifying a scientific problem. The learner also learnt how to modify problems so that they are testable. Unless a learner received a solid foundation in planning on how to solve a scientific problem, then the learner may not develop the other creative skills well since they are based on it.

The instructional modules teaching was to be conducted at a time when learners would have sufficient time not only to carry out the tasks set before them, but also to pool their results, make corrections and additions in their work sheets where necessary. The compiled group

reports would be handed over to the teacher in the module lesson that would follow. Before any experimental apparatus were supplied out to the students, some amount of time had to be allowed for them to discuss the modules and put forward their own requirements. One important role of a teacher during the CTS lesson was that one of a team leader. The teacher was expected to direct the learning process in a group towards creativity goals but not to give them direct suggestions; the teacher was also expected to enlighten the learners on the possible lines of thought, for example the teacher would encourage them not just to think in terms of the conventional laboratory apparatus, but rather to come up with all manner of modified and improvised apparatus. The teacher was also expected to challenge the learners to use the suggested locally available and improvised apparatus in an attempt to solve a problem creatively.

The prepared creativity teaching modules were to cover at least twelve lessons within a span of three weeks, but the study would deem 75% coverage of the lessons as being sufficient for it to make a comparison. The study encouraged the two teachers involved to ensure that all the module lessons were taught. From the results of the pilot study, the study was able to gauge the effectiveness of the teaching modules. Some modifications and changes were made in the modules to remove ambiguity and other organizational problems after the piloting stage. The following specific areas were addressed: the whole content was reorganized; some modules had their content coverage either increased or reduced; some module lessons were edited and the pace of module lesson coverage was slowed down in some lessons. All these changes were effected in close discussions with the teachers who were involved in the pilot study and their views were fully incorporated when making the final draft of the teaching modules.

3.8.5 Post-Test Administration

After the creativity instructional strategy had continued for at least three weeks, the researcher felt it fit for the post test to be administered. For a learner to sit for the post test meaningfully and for comparison to be made, they ought to have been exposed to at least 75% the creativity instructional strategy modules. The first five lessons were core to the instrumental strategy. The post- test instrument (coded 'springs') accompanied by the PSAQ questionnaire was administered to the respondents in all the groups; however, due to the differing school programmes, the instrument could not be administered on the same day. But

there was no fear of contamination since the groups were located in schools that were far apart and the students would hardly interact after school hours. Any use of communication gadgets such as mobile phones would be minimal as the students would feel the task ahead of them is not as threatening as a National Examination situation. Once more again the researcher forwarded the instruments few minutes to the time when the learners were to respond to them. The researcher also ensured that all the scripts handed over to the learners were collected back after they reacted to them. The post-test, just like the pre-test, was also allocated a maximum of 50 minutes for the learners to respond to it. No more time was allowed beyond the allocated one. Students were continuously encouraged to take their time and put down all what they considered as a response to the problem without fear of either failing or upsetting the examiner by giving an absurd response. The response rate in the post test was found to be over 95%. In this study a response rate of over 75% was deemed sufficient for the study to allow for a generalization to be made.

3.9 Data Analysis

The following steps were followed during the analysis of the data obtained in the course of the study. First, the schools were coded in a way that their true identity was concealed and each code represented a particular school. School K, school R and school P were codes used to refer to schools carrying the control group (C_1), the second control group (C_2), and the experimented group E respectively. After the answered scripts were collected from the individual learners, the researcher scored them and the score for each aspect of creativity achieved by each learner indicated on the script. Under the creativity aspect of planning for a scientific investigation, the researcher indicated the number of relevant equipment set-ups mentioned in the answered scripts, while under the aspect of sensitivity, the researcher indicated the number of relevant sources of error given by each respondent. To ensure that the expected responses were used during the data analysis and no exaggeration or false data was entered for analysis, the data obtained was organized, where misplaced entries were checked and if possible relocated or placed in their rightful places. The marking of answered scripts from learners and recording of the scores was done manually by the researcher but to carry out the data analysis, computer help was sought. This was because computer use is more accurate, saves time, gives neat work and minimizes human errors.

3.9.1 Scoring the Students' Responses

Once the post-test responses were collected, the researcher could then continue to the next level i.e. data analysis. This involved scoring the scripts in pre-test and post-test following a marking scheme prepared by the researcher and the teachers involved in the study. The scoring criteria for both pretest and posttest are outlined in appendix B-4. As it had been noted earlier on, each instrument had presented one question which the respondents were to solve by reacting to a set of six sub questions numbered from number one to six. Each one of these questions represented a certain aspect of creativity under investigation, for example questions 1, 2, and 3 required a learner to state what apparatus would be used, the particular types of measurement, and how they should be undertaken; this was to test the creative skills of planning and relationships. Question five required a learner to state what should be done to ensure a fair test is conducted. This sub question tested whether the learners possessed the creative aspect of planning for a scientific experiment. Sub question six that required a learner to state some sources of error that might have affected the experimental set up tested whether the learner had acquired the creative skill of sensitivity towards a scientific problem.

There was no marking scheme prepared for the PSAQ instruments since the learners responses were to be in accordance with their feelings at that particular moment. They were to respond by making a choice from the responses set out in the form of a likert scale. Since all the questions were positive, a strongly agreed or agreed response yielded a positive attitude towards the stated issue; while a strongly disagreed or disagreed response yielded a negative attitude towards the stated issue. The researcher scored all the scripts above and recorded each respondent's individual score in the script, the scoring was done in a general way that marks were awarded according to the number of correct responses forwarded as per the marking scheme, and then the marks on each script were transferred to a register. As it can be seen from the register, under the creative abilities of a learner, entries were made for parts 1, 2, 3, 4, 5 and 6. Each one of these parts represented a certain creative ability. The study was mainly concerned with part 5 (which represented a learner's creativity aspect of planning for a scientific investigation and part 6 (which represented the learners' creative aspect of sensitivity towards a scientific problem).

For part 5 in the test instruments, a respondent was expected to give at least ten (10) control variables to ensure that a fair experiment was conducted and such results accepted as being a

true representation of the experimental set-up; while for part 6, a respondent was expected to criticize his/her experimental set up by giving at least ten (10) sources of errors that could have affected the experimental set-up and influenced the results. Each correct response in part 5 and 6 earned a respondent one mark (or a score). Each one of these parts representing an aspect of creativity was therefore scored out of ten. For the responses in the PSAQ questionnaire, the researcher prepared a contingency table and entered the responses under the head columns of (strongly agreed (SA), Agreed (A), Undecided (UN) disagreed (D) and strongly disagreed (SD).

3.9.2 Interpretation of the Collected Data

The scores for learners in each of the creativity skills were recorded for each group in a tabular form; a table was constructed to record the results for groups C₁ and E in the pre-tests. The post-test scores for individual students in groups C₁, C₂ and E were recorded in a similar table. The pre-test and post-test results obtained for groups E and C₁ were then compared to analyze any differences between them. The results obtained from the second control group (C₂) were used to make comparisons with the results obtained in the control group (C₁) and experimental group (E) so as to control for the influence of pre-testing on the experimental group that is the interactive effect. To check for the equivalency between the groups at the beginning of the study, a t-test for the differences between the means of the pre-test scores for group E and C₁ was performed. The same t-test was applied to find out whether the differences between the post test control group C₂ scores and experimental group E scores were significant.

Once the pre-test equivalence test had been carried out, the post-test results obtained were then subjected to a t-test and analysis of variance (ANOVA), so that the differences between the performances of control group (C₁) and treatment group E could be analyzed further (by eliminating the influences of sampling error). The influence of creativity teaching strategy on learners' development of creativity skills of planning and sensitivity was then checked by performing an Analysis of Variance (ANOVA) for the scores obtained in the post-test data. When the ANOVA value was calculated from the data, it was compared to the critical F-value from the tables at the significant level of $\alpha=0.05$. If the calculated F values would be greater than the critical value from the tables, the null hypotheses H₀₁ and H₀₂ would be rejected and the difference between the control group C₁ and the experimental groups E

would be significant. The study would then conclude that the treatment influenced the experimental group significantly. If otherwise, the difference could have been due to sampling (chance) error and not entirely due to the treatment.

For the analysis of the data obtained from the PSAQ questionnaires, the chi square (χ^2) test was used: first, the raw data was organized and grouped; this was to ensure that all the responses in the questionnaires were in order i.e. misplaced pages and answers were identified, and put in their rightful positions or else removed to avoid any incidence of confusion. A contingency table was then constructed for the data to allow for the analysis to be carried out. A strongly agreed (SA) or agreed (A) response meant that the learner had a positive attitude towards the stated issue while strongly disagreed (SD) or disagreed (D) yielded a negative attitude in the same way. Undecided (UN) response was not put in either way. The contingency table was then constructed for the positive and negative attitudes to allow for the analysis of the data using chi square (χ^2) test. A more positive χ^2 value obtained would refer to a bigger influence of the CTS on the learner motivation and rejection of the 3rd null hypothesis, H_{03} . A more negative χ^2 value obtained would refer to a lesser influence of the CTS on the learner motivation. Table 6 shows the statistical methods used to test the hypotheses in the study. The independent variable were teaching and learning methods, the dependent variable was students scores in achievement test and motivation to learn physics. Extraneous variables in the study were school, learners and school conditions.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

“The influence of the Creativity Teaching Strategy on students' performance and motivation in the topic ‘energy’ in secondary school physics” was assessed through critical analysis of the results obtained after training students following a Creativity Teaching Strategy. The results discussion shall focus on three main areas:

- a) Learners' performance on the two aspects of creativity that the study dwelt on mainly that is sensitivity towards a scientific problem and planning for a scientific problem.
- b) The influence of the strategy on learners' motivation.
- c) The influence of the strategy on the other aspects of creativity that the strategy did not put much emphasis on.

The influence of the Creativity Teaching Strategy on learner's performance and motivation was checked by assessing the performance of the learners in both control and experimental groups during the pre-tests and post-tests. This method of assessment had been used previously to assess the influence of Concept Mapping Teaching Strategy on learners' creativity (Okere & Abuto, 2005). As it had been stated earlier on, the creative aspects of sensitivity and planning for a scientific problem can be assessed amongst learners by analyzing their responses towards sub questions 5 and 6 in the test instruments, while the motivational aspects of the learners can be assessed from their responses in the PSAQ questionnaire. The other aspects of creativity that were not pertinent to this study shall only be mentioned and highlighted where necessary. To start off the discussion on the results, the study shall at first present its findings in the pretest and then at the posttest. It's also worth to remember that at the piloting stage, the teachers involved were instrumental in making the necessary modifications to the instruments; therefore the study found it fit to briefly discuss the findings at the piloting stage. Section 4.2 below discusses the pretest results.

4.2 Results of the Pre-test

The pre-test instrument had two parts i.e. the open ended design of investigation (coded ‘Marble’) and the Physics Self Assessment Questionnaire (coded the ‘PSAQ’).

The problem presented in the 'Marble' required learners to come up with an experiment to test a scientific problem involving a marble falling through various types of liquids. The learners were to solve the task by responding to a set of six questions which cut across the four aspects of scientific creativity as outlined by Okere (1986). The responses were then scored following a marking scheme prepared by the researcher and the teachers. Part 1 of the test required a learner to put down all the apparatus that might be relevant in the experimental set up thought about. The respondent was expected to forward at least twelve relevant types of apparatus to be involved in the course of the experimentation. A mark was awarded for any relevant type of an apparatus mentioned, whether found in the conventional laboratory set up, a modified type of an apparatus or even an improvised one (Gil *et al.*, 1991 ;Wheatley, 1991). For example the use of a cup, glass tumbler or an empty cooking fat container as possible beakers or flasks would be acceptable and treated as a correct response.

Part 2 of the test checked whether the respondent knew what quantities should be measured in an attempt to solve the problem. The responses expected here included length, mass, height, time, volume, distance. This sub question, apart from checking on the creative aspect of planning, would also check on the creative aspect of recognition of relationships, since for each type of measurement mentioned, there must be a specified type of an apparatus or an instrument associated with it. Also if a type of measuring instrument mentioned is not calibrated or graduated, it should be used in collaboration with another one that is calibrated. This sub section was also in line with Torrance's tests, especially the ones on the improvement of the quality of an item (Torrance, 1977). Part 3 of the test instruments required a learner to show how the various measurements mentioned should be obtained. This would test for the creative aspect of showing relationships, since each measurement should be associated with a particular type of a measuring instrument. For example length should be associated with such measuring devices such as metre rule, strings, palms, strides, micrometer screw gauge, vernier calipers, tape measure etc. Any one of these measuring devices or methods was taken to be correct at this stage and earns the respondent a score, since they showed that the learner is able to think in abstraction for possibilities. Craft (2000) had pointed out that the ability of a learner to think in abstraction and come up with possibilities indicates that such a learner possess some creative abilities.

In part 4 of the test instruments, a respondent was required to state how he / she shall arrive at the results. This was the point at which calculations and other forms of explanations having a scientific bearing were to feature in an attempt to solve the problem in their own way. In other

words the learners were required to make a link between observed scientific phenomena to either already existing scientific laws and principles or make their own conclusions. Claxton (1999) had described this as the ability of a learner to define the most graphic manifestation of their power of imagination. This part to a greater extent tested the creative aspects of flexibility in reasoning and of showing relationships. Flexibility would be shown by the number of methods forwarded to solve the problem, be it mathematically or through verbal explanations (Okere, 1986). The learners were expected to forward at least three workable methods of solving the problem.

In part 5 of the pretest instrument, a respondent was required to state the control variables to ensure that a fair experiment was carried out and accurate results were obtained (Okere, 1986; Torrance, 1977). This was the part that justified the type of instruments used and their accuracy. It also justified the methods used to solve the problem. If the control variables forwarded were relevant and within the limits of the measuring instruments, then a fair experiment would be conducted within the limitations of the instruments and in that case the method followed would also be justifiable. If no control variables were forwarded, then the ability of a learner to carry out a fair test (or experiment) is in jeopardy and the whole process of planning for an experiment questionable. This explains why the study chose this part to check for the creative aspect of planning; a creative learner was expected to forward at least ten control variables to enable a fair experiment to be conducted. This was in line with the previous experiments that tested various aspects of creativity (Okere, 1986).

Finally the sixth part of the question required a learner to state the sources of error in the experimental set up they come up with. This part of the question assessed the creative aspect of sensitivity towards a scientific problem. A learner who manages to forward a number of sources of error exhibits this aspect. Sources of error varied widely and touched on many areas such as on the types of instruments used, measurements taken and even on the accuracy of the methods used to arrive at conclusions. The higher the number of the sources of error forwarded by a respondent, the more sensitive that respondent is deemed to be towards that scientific problem (Okere, 1996). A respondent was expected to forward at least six sources of error in the experimental set up that they came up with for their conclusions to be accepted within their experimental errors. Table 7 shows the average scores of the learners in various groups in the pretest.

Table 6: Average Scores in Pre Test for Various Groups in Different Aspects of Creativity

	1	2	3	4	5	6
Aspect group	(x/12)	(x/12)	(x/10)	(x/3)	(x/10)	(x/10)
C ₁	6.5	2.1	1.7	0.12	1.9	1.2
C ₂	-	-	-	-	-	-
E	7.3	2.5	1.8	0.4	2.1	0.8

The scores above showed that learners performances are extremely low in all aspects of scientific creativity. Part 1, 2 and 3 of the questions required a learner to isolate and interpret the problem and outline how to go about solving it. The solutions given by the learners would tell whether the learners possess the creativity aspect of planning for a scientific problem. Part 1 of the question required the learners to state the apparatus that they would use to solve the presented problem. Out of the twelve expected apparatus, more than half of the respondents were able to give at least six relevant apparatus. Part 2 of the question required learners to mention what measurements would be taken in order to solve the problem. At least four of the ten expected measurements should be given for a meaningful experimental set-up. More than 80% of the respondents were not able to give the four expected measurements. The same case was noted in aspect 3 which required a respondent to state a suitable measuring device for the type of measurements stated above. This implied that many learners knew how the required apparatus would look like, but could not go a step further (on their own) and explain what type of data (or measurement) would be obtained using such apparatus.

Since the learners knew the apparatus, it meant that teachers do not go a step forward and challenge the learners to use the apparatus or their improvisation to obtain measurements. The results were in agreement with the previous observations that teachers are responsible for their learners productivity (Craft, 2001) and also that learners creative ability can be improved by a teacher through training (Craft, 2001; Okere & Abuto, 2005). The fourth aspect required a learner to give relevant methods on how the presented problem would be solved. Out of the 114 student respondents, only 23 students were able to forward a workable method of solving the problem. This translated to only 21.5% of the total students being able to forward a workable solution to the problem (see table 8 below). 78.5% of the students' population could not solve the

problem. Aspects 2, 3, and 4 assessed the creativity aspect of recognition of relationships and flexibility in reasoning. Just like in the previous results, the results obtained in this study implied that students are neither flexible nor associative when faced with a novel situation (Ndeke, 2003; Okere, 1986). The students were expected to forward a minimum of three workable methods to solve the problem. The fifth part of the question required a learner to give the control variables which would allow for a fair experiment. This part was to test for the planning aspect of scientific creativity. Learners were expected to forward at least ten control variables. Majority of the respondents (80%) could not go beyond four control variables. At least five control variables were required for a fair experiment to be conducted. This implied that majority of our students may not carry out a fair investigation experiment when required to do so. Previous studies have attested to a similar scenario (Okere, 1996; Craft, 2001). Table 8 below shows the summary of the average percentage scores obtained by the respondents in various aspects of creativity for the true control and the experimental groups:

Table 7: Percentage Scores of Respondents in the Aspects of Creativity in Groups C₁ and E

Aspect	C ₁	E
Planning	20%	22%
Relationships	18%	20%
Flexibility	21.5%	23%
Sensitivity	12%	8%

In the experimental setups that the learners came up with, the variables were mixed up and it became difficult to understand what factors were in play and which ones were confounding the results of the others. The last part of the question (part 6) required a learner to state the sources of error that could have affected their results in the experiment. They were expected to identify at least ten sources of errors. 60 respondents out of 114 could not think of any possible sources of error in their experimental set ups, while the rest could only give between zero and three sources of error in the experimental set ups they had outlined. The results obtained appeared to suggest that the concept of ‘sources of error’ is new to most of our students; and therefore teachers should be encouraged to train their students in it. In general, the pretest results showed that our learners are not being trained to be creative; a large percentage of them do not exhibit any of

the aspects of creativity, they are poor at planning for an investigation (80%), not flexible in reasoning (78.5%) and finally do not show adequate sensitivity towards scientific problem (92%). The results indicate that learner performances in the aspects of creativity are generally low, an observation that is in agreement with the previous studies (Okere, 1996; Okere & Abuto, 2005).

4.3 The PSAQ Questionnaire

Upon collection and organization of the data in the PSAQ instruments, the responses were grouped into two broad categories i.e. positive attitude and negative attitude, where strongly agreed and agreed responses constituted the positive attitude and both strongly disagreed and disagreed responses were grouped under negative attitude category. Conventionally a positive response would indicate a high motivation (interest) level since the questions set in the questionnaire were all positive and conversely negative responses represented a low motivation level. Such grouping would enable data analysis to be easier. The recent change in the secondary school curriculum has made it possible for learners to choose two of the three science subjects for them to pursue to the KCSE level (KIE, 2002). This means that a student pursuing a particular science subject had made a deliberate choice to pursue it at a certain level in the course of their study. This allowance has affected physics negatively since it's traditionally viewed as the most difficult science subject (Ryu, 1987). Also the compatibility of physics with the other science subject puts it at a disadvantage since mostly it can only be combined with chemistry. We therefore expect that those learners who chose to pursue Physics in their own volition would maintain a high interest level in it.

The data collected from these questionnaires at the pretest showed that the learners' motivation in the subject is quite high; positive attitude responses were three quarters of the total responses, while the negative attitude responses were only a quarter of the total responses. This meant that the students already had high motivation in the dimensions being investigated. The students are allowed to choose to pursue physics on their own volition; therefore those who chose to pursue it do it willingly and therefore holding all other factors constant, their interest level is expected to be high. After a brief discussion on the situation of creativity amongst the respondents, the study can now focus on the effects of the CTS on learners since the purpose of the study was to check whether CTS would improve the learners' creative abilities. The study will do this by first discussing the results of the post test and then drawing a comparison between them and those of the pretest. Any difference between them was then subjected to ANOVA test to ascertain whether it arose from treatment or from the sampling error.

4.4 Post Test Results

As it was discussed earlier on, the post test instrument coded ‘springs’ was similar to the pretest one in all aspects except the problem presented; the presented problem here involved some masses falling on a spring held upright. The Pearson’s moment correlation between the two instruments after piloting was found to be 0.8, which was in agreement with the required level of at least 0.7 in experimental studies (Cook, 1976). The six set of sub questions presented in the posttest intended to achieve the same objectives as those ones in the pretest. The study would therefore not discuss the sub questions here but shall discuss the findings and since the study was only interested in the creative aspects of planning and sensitivity, only sub question 5 (which tested planning) and sub question 6 (which tested sensitivity) shall be discussed here. In general, post test results in the experimental group showed a positive improvement in the learners' performance. The table below shows a summary of the scores for the groups in various aspects of creativity in the posttest:

Table 8: Average Scores in Post Test for the Various Groups in Aspects 5 and 6

Group	5	6
Aspect		
C ₁	1.475	1.130
C ₂	2.900	1.677
E	2.450	2.100

The post test items were similar to the pretest items and deemed to be at the same level of difficulty (the correlation between them based on students performance in the pilot study using the K-R-21 formula was found to be 0.78). In the post test, the students were still required to respond to the six parts of the problem as outlined in the pretest above and the scoring was done the same way. They were also to respond to the same PSAQ questionnaire. Both the experimental group and the second control group attained significantly higher scores than the control group C₁ in all the aspects. 60% of all the respondents in the experimental group improved their scores in all the parts except in part 4, where majority of students still wouldn't forward a workable method. The responses for the various parts in the control group C₁ remained fairly consistent in both the post test and pretest.

4.4.1 Effects of Creativity Teaching Strategy on Learners Performance

The performance of the learners in the control group C₁ remained fairly consistent in both the pre test and post test, but the performance of the experimental group differed significantly in both pre test and post test. Equally the second control group C₂ showed a comparable higher performance in post test as the experimental group did (see table 10).

Table 9: Average Score in Aspect Five and Six

Aspect Group	5 (Planning)		6 (Sensitivity)	
	Pre-test	Post-test	Pre-test	Post-test
E	1.600	2.45	0.700	2.100
C ₁	1.474	1.475	1.035	1.13
C ₂	-	2.90	-	1.677

From the table, the average score of the respondents in the creative aspects of planning was 1.60 in the pretest which improved to 2.45 in the posttest in the experimental group. But in the control group C₁ the scores remained fairly constant at 1.474 and 1.475 in pretest and posttest respectively. For the creative aspect of sensitivity, the experimental group improved its score from 0.70 in the pretest to 2.10 in the posttest. The control group C₁ had very close performances in the pretest and posttest being 1.035 and 1.13 respectively. The treated control group C₂ had significantly high scores than group C₁, but comparable to those of group E. since the control group C₂ showed significantly higher performance, it means that the improved performance after treatment could be attributed to the treatment given and not due to pretest sensitization since this group (C₂) had not been pre tested. The data from the tables show that the scores for the experimental group improved significantly, while those of the control group C₁ remained fairly consistent. Therefore, the study made a conclusion that the CTS improved students' creative ability of sensitivity and planning when faced with a novel situation. The improved performance was evident in the two aspects of creativity tested.

It is note worthy to report that aspect number six that required learners to give sources of error that would have affected their experimental set up presented a higher difficulty level

than aspect number five which required them to give control variables. This was in agreement with the previous results from similar studies that show that planning, use of results, and sources of error form a hierarchical model where naming of sources of error come as a result of proper planning (Okere, 1996). Sternberg (1996) discussed results that supported the findings of this study, where he found that learners would prefer to learn following the creativity strategies rather than memorise information provided by a teacher. Before the treatment commenced, the three groups were compared to ensure that they were at the same level of performance. A t-test was therefore applied to the scores obtained during the pretest for the control group C₁ and the treatment group E. The t-test showed that the scores of the control group C₁ and E were comparable at the start of the study as seen in table 11 which gives a summary of the t-test results in pretest between groups E and C₁:

Table 10: A t- Test for the Comparison of the Pre Test Means of Groups C₁ and E

Variable	E: N=31;	C ₁ : N=41;	X ₁ -X ₂	t _{calc}	Significance 2-tailed
Aspect	X ₁ =	X ₂ =			
Planning	1.600	1.474	0.126	0.604	0.95
Sensitivity	0.700	1.035	-0.335	0.700	0.95

Critical values ($\alpha =0.05$, p = 1.875, df=40)

This method of comparison has been used in previous studies, and is suitable for this type of experimental data analysis (Cook & Campbell, 1979). Likewise the results obtained using the PSAQ instruments were also compared to ensure that the groups were at a close motivational level at the start of the study as Table 12 below attests.

Table11: Comparison of the Positive and Negative Responses Obtained in Groups C₁ and E at the Pretest

Variable group	Positive responses	Negative responses	total
C1	936 (86%)	144 (14%)	1080 (100%)
E	716 (82%)	64 (18%)	780 (100%)

The results showed that in both groups, positive responses out stripped the negative responses, implying that the learners' motivation was already high even before the treatment commenced. This was probably due to the fact that learners had made a personal choice to pursue the subject as already discussed earlier (ROK, 1999). After ascertaining that the two groups were comparable at the start of the study, the treatment followed in both treatment and the second control groups for a period of three weeks, after which the posttest was administered. A t-test was once more again applied on the data obtained from the post test for the groups followed by an ANOVA test. Table 13 gives a summary of the data obtained after the t-test was applied in the posttest data of control group C₁ and E:

Table 12: A t- Test for the Comparison of the Post Test Means of Groups C₁ and E

Variable	E:	C ₁ :	X ₁ -X ₂	t _{calc}	Significance
Aspect	N=31	N=38			2-tailed
	X ₁ =	X ₂ =			
Planning	2.450	1.475	0.975	5.128	0.95
Sensitivity	2.100	1.130	0.97	4.200	0.95

Critical values (α =0.05, p = 1.875, df =72)

The t-test performed on the post test data showed that there was a significant difference in the performance of the experimental group at pretest and posttest in the two aspects of creativity which was not the case in the control group C₁. Tables 11 and 13 above show that groups C₁ and E were comparable at the start of the study but the difference in their post test performance was quite significant. The scores of the control group C₂ and E were found to be comparable at the end of the treatment as shown in table 14:

Table 13: A t-Test for the Comparison of the Post Test Means of Groups C₂ and E

Group	E:	C ₂ :	$X_1 - X_2$	t_{calc}	Significance
Aspect	N=31; $X_1 =$	N=42; $X_2 =$			2-tailed
Planning	2.450	2.900	-0.45	1.28	0.95
Sensitivity	2.100	1.667	0.433	1.24	0.95

Critical values ($\alpha = 0.05$, $p = 1.875$, $df = 73$)

The results provided in Table 13 above means that the differences between group E and C₁ could be attributed to the treatment given to E but denied to C₁. In order to check for the effect of CTS on students' performance in the tests, an analysis of variance (ANOVA) was performed on the post test data. This was to ascertain that the differences in the performance of the groups were due to the treatment unlike sampling error or any other factors. Table 15 gives a summary of the data obtained after the ANOVA test was performed.

Table 14: ANOVA of CTS Post Test Means for the Three Groups

	Sum of squares	df	ms	F	P value
Between Groups	42.166	2	21.05	26.25	-
Within Groups	189.19	218	0.87		
Total	231.356	220			

Critical values ($df = 2, 218$; $p < 0.05$, $F = 2.68$)

The calculated F value was 26.25. This was greater than the critical values from the tables. The results from the tables are clear: that the differences in the performance of the control group C₁ and the experimental group E at the post test were significant at the $\alpha = 0.05$ significance level whilst the ones between the second control group C₂ and the experimental

group E did not differ significantly at the same level of significance. The study therefore drew a conclusion that the CTS had a significant influence on the performance of learners within the significance level of the study. The t- tests applied showed that the experimental group (E) and the control group (C_1) had a significant difference in their performances at the posttest in the two aspects of creativity tested in the study. For the first hypothesis H_{01} , the t- test value obtained was 5.128 against a critical value of 1.875 from the t- tables. Therefore the study did not provide data that supported H_{01} and the hypothesis was therefore rejected leading to a conclusion that CTS improved learners' creative aspect of planning for a scientific investigation. For the second hypothesis, H_{02} the t- test value obtained was 4.200 against a critical value of 1.875 from the tables. Again the study did not provide data that supports H_{02} , leading to the rejection of the hypothesis and a conclusion that CTS improved learners creative aspect of sensitivity towards a scientific problem significantly. The study concluded that the Creativity Teaching Strategy did influence the creative aspects of sensitivity and planning amongst the students significantly. Since groups C_2 and E were comparable after the treatment, the pre test sensitization as a source of the difference was controlled for. Also the ANOVA test ruled out the likelihood of the difference having occurred due to chance.

The study therefore concluded that CTS improved learners' creative abilities of planning and sensitivity after they were taught following it; this was a conclusion that supported the assertion in findings of the previous studies that creativity is a skill that can be taught to learners (Guiford, 1952; Ryhammer & Brolin, 1999). These researches had found out that creativity could be fostered to learners through specific teaching approaches. The results obtained from learners responses in aspect 5 on planning were used to evaluate H_{01} while the responses from aspect 6 on sensitivity were used to evaluate H_{02} . The results obtained also implied that the educational systems train learners on how to plan for a scientific investigation but rarely put emphasis on the aspect of sensitivity. Such an anomaly could be rectified through a Creativity Teaching Strategy. In general, before the Creativity Teaching Strategy was implemented, the learners' creative abilities were found to be quite low in all the aspect; majority of learners had scored between 0% and 20% in most of them; but the scores improved to between 20% and 40% after training as exhibited in both the experimental and second control groups. The results were consistent with the previous studies which indicate that secondary school learners have low creative abilities in science subjects (Okere, 1986; Okere & Abuto, 2005).

The scientific creative abilities of learners have also been found to improve after training following some teaching approaches such as Concept Mapping (Okere & Abuto, 2005). The remarkable improvement in learners' creative abilities in both the planning and sensitivity abilities in the topic 'energy' among the Form Three physics students when trained through the Creativity Teaching Strategy means that the regular teaching approaches do not train KCSE graduates in creativity sufficiently. We can still enrich out conventional teaching strategies with instructional approaches that would enable them to foster creativity amongst students. The secondary school Physics curriculum only hope that the learners will be able to develop their creative abilities after they are exposed to the practical, projects and exercises that are outlined in the learners' course books (ROK, 1999). The creative activities included here have been found to be insufficient and no methods of assessing them have been forwarded.

4.4.2 Effect of Creativity Teaching Strategy on Learners Motivation.

The learners' responses were grouped into two broad categories i.e. positive attitude (which consisted of strongly agreed and agreed responses) and the negative attitudes (which consisted of disagreed and strongly disagreed responses). The positive attitude responses were deemed to indicate same level of motivation in the stated issue, while negative attitude responses, indicated some level of de-motivation. This method of comparison had previously been used to compare the motivation levels of learners in mathematics (Githua, 2004). The table below indicates the total positive and negative responses in the groups and their corresponding percentage values both in pre-test and post test:

Table 15: Positive and Negative Responses obtained from Various Groups

Group/Test		C ₁	E	TOTAL
Pre-test	positive	936	716	1080
	%	86.0	82.0	
	negative	144	64	
	%	14.0	18.0	
Post test	positive	1046	614	1134
	%	92.0	92.7	
	negative	88	48	
	%	8	7.3	

During the post test, some students were found to have shifted their responses from negative to positive and therefore the positive percentage values of the responses increased. A higher percentage value meant that there was a bigger influence on motivation from the interest of learners, while a lower percentage value would mean that there was less influence of interest on motivation. A higher percentage value meant that the tendency of learners to belong to a particular group increased, while a constant percentage or reducing one would mean that the likelihood of learners belonging to a particular group was not changing and tended to remain the way they were. The data obtained from the PSAQ questionnaires showed change in the learners' feelings after the Creativity Teaching Strategy. Since the data yielded a conclusion that a response obtained was dependent on the group, then the third hypothesis of the study (Ho3) was not supported, and the study concluded that the Creativity Teaching Strategy influenced the learners' motivation in the topic significantly. The positive scores for the control group C₂ were significantly higher than the ones for control group C₁ and were not significantly different when compared to those of group E. Therefore, the differences between C₁ and E could only be attributed to treatment and not on pre test sensitization.

Learners' motivation during physics topic 'energy' was found to be significantly higher during the pre-test and post-test. The dimension of motivation checked in the study was interest which was assessed by comparing the scores in part one (i.e. the first five questions) of the PSAQ questionnaire both in pre-test and post test. Table 17 gives the results obtained after the data obtained was analysed using the chi square test.

Table 16: Chi Square Test Results for both Pretest and Posttest PSAQ Data Analysis

Pretest	Posttest
χ^2 calc (df=1) = 0.090	χ^2 calc (df=1) = 0.15
χ^2 critical (df=1) = 0.00393	χ^2 critical (df=1) = 0.00393

Critical value (α =0.05, df = 1, χ^2 = 0.00393)

Though the change was not significant when tested using the chi square test, the Creativity Teaching Strategy influenced learners' motivation in the topic, but not to a significant level. This might be explained by the fact that learners had chosen physics subject earlier on under their own volition; their attitude and interest towards it would remain fairly stable since they would feel it is their obligation to retain interest in the subject under all situations (ROK, 1999; Vernon,

1970). Therefore the study could conclude that the Creativity Teaching Strategy improved the motivation level of students during the physics lessons taught under the topic of 'energy'.

4.5 Responses Given by Teachers and Students on Their Views on CTS

To support the empirical findings of the study, this section presented the views of teachers and students who took part in the study in an attempt to capture their feelings towards it. The easier way of assessing teachers and students responses on CTS would be to discuss the views collected from each group in the courses of the study. The survey method of collecting research data was found fit and used in this case since the research intended to collect views that would be better expressed verbally than would be in a written form (Koul, 1984). This method also provided invariable data for the research. The study would now start by discussing the views collected from the experimental group E in school F.

4.5.1 View of Teachers and Students on CTS in Experimental Group, school F

After teacher induction, the teacher in this group felt that the teaching approach would be more resourceful in his teaching methods and also felt that the modules were well prepared and within the comprehension level of the students. The teacher looked forward to start teaching following the strategy. The teacher also felt that the effectiveness of the modules would be tested adequately using the type of the instruments provided. The teacher agreed that the modules were a deviation from his day to day set of experiences that he provided to the students and hoped that the students would internalize the concepts and ideas behind the modules. In the course of the modules teaching, the teacher noted that the learners were highly excited especially when handling a task that was structured in a form of work sheet which required them to devise, carry out and criticize their experimental set-up in small groups. The teacher was therefore in agreement with the previous studies that suggest that learners should be involved in the practical work to a greater extent (Okere, 1986); also the classroom features should be in such a way as to elicit creative thinking amongst the learners (Torrance, 1977).

After the first two lessons, the students had already adjusted to the lessons and anxiously waited for the other lessons. This was indicated by the excitement that followed after the teacher gave out the subsequent tasks to the learners and left them alone to work in small

groups. The teacher also noted that the learners were not eager to give the sources of error that might have affected their results; they took their results with finality. The learners were not able to understand easily the meaning of the phrase 'sources of error' in an experiment. At the end of the study, the teacher reported that the teaching approach was quite interesting and a possible strategy that could be used to teach physics to students more effectively. Sternberg and Lumbart (1996) had also found the same results and stated that pupils learn better and even sometimes faster when exposed to some creative activities.

The learners who were interviewed in the course of the study agreed that they had enjoyed learning the topic 'energy' following the strategy; they agreed that the teaching modules were interesting and gave them challenging situations that they rarely came to think about in their daily life. They also agreed that they'd wish to continue learning physics following such modules. They appreciated the kind of tests given here and looked forward to receiving back the marked scripts and observe the marking scheme for the test. The learners also agreed that in the course of their study following the modules, they no longer viewed the teacher as the source of all correct answers, but felt that they were a part in looking for the answer. They also felt that the modules fully preoccupied them at all the times, both mentally and physically especially when they were thinking about the possible setups; making, recording, discussing observations and also when making inquiries from their neighboring groups.

4.5.2 Views of Teachers and Students on CTS in Second Control Group, School P

In this group, the teacher agreed that the test implement would measure learners' performance adequately. The teacher was also eager to implement the strategy and observe the reaction of his pupils. The teacher agreed that the strategy was easy to comprehend and follow and therefore he expected that the students would adjust in it within a short time. The teacher taught the module lessons each day between 7.20 a.m. to 8.10 a.m. since he did not want it to interfere with the normal school programmes. The teacher also agreed that the modules were quite detailed and linked the topic areas coherently and would be easily taught to his students.

The teacher reported high participation levels from the entire class, meaning that the strategy was able to appeal to students from all levels of achievement in the class. This was an observation that other researches earlier on had come up with; pupils were found to be more attracted to the creative activities which bring in variations, unlike the usual study methods that insists on

cramming a set of pre prepared set of facts (Craft, 2001). The learners were also positive about the lessons in the topic 'energy' and said that it excited and elicited their thinking skills. The teacher agreed that the method closely resembled the ASE1-PDSI teaching approach which is being advocated for in the on going SMASSE project and would be quite suitable in teaching some of the abstract scientific concepts since it challenges the learners to think in all spheres of possibilities. The learners' responses indicated that they were actively involved in building up concepts which made learning more enjoyable than when a teacher gives a set of concepts to learners to internalize without any fore foundation on the ideas. The learners also requested to be given the marked scripts to see how they fared on in the tests.

4.5.3 Views of Teachers and Students on CTS in Control Group C₁, School K

This group was not taught following the CTS, but its views pertaining the pre tests and post test instruments were collected. The teacher was very positive about the pre test and post test instruments since they represented a departure from the traditional trend of perceiving physics as a numerical based subject; the teacher was in agreement with suggestions put across earlier on that the definition of creativity should cut across many areas, especially in the awareness of ones knowledge on environmental and social contexts (Ryhammer & Brolin, 1999). The teacher wondered how the questions would be tackled without any numerical calculations - especially the aspect number 4. The teacher alluded that her students had a tendency of solving any physics problem in terms of calculation and they may feel that verbal explanations may not suffice. Ryu (1987) also described the view of many people who assume that physics is a numerical based subject. This was evident on the pre-test responses. The teacher agreed that the questions widened the learners understanding of scientific problem in that apart from straight forward answers or numerical based responses, there were other sets of responses that once linked together can lead to knowledge creation and concept formulation. Gallagher (1994) had said that Physics should be treated as a way of thinking unlike a subject with a rigid set of knowledge to be transmitted. The learners appreciated the tasks set out in the pre test and post test and agreed that the tests tested them within their ability. They also agreed that the test would help them shape the kind of responses they gave to a scientific problem; they agreed that with adequate training they could be competent enough to solve such problems in future. They wished that they were allowed to answer the question in the post test in small group work.

4.5.4 Summary of the Views Expressed in the Study

The responses given by learners were also highly limited to things they learn in their academic work. The learners showed no evidence of thinking beyond their classroom work. Most of the apparatus they mentioned were the ordinary ones found in their school laboratory and learners would not think on any line to do with improvisation or recycling of materials within their environment. One study group indicated that learners viewed solution to a problem in terms of calculations only. Even in situations where calculations were not expected, some went on to carry out some sort of calculations. These observations might be due to the regular teaching strategies applied by teachers in the course of their lessons. The following table, adopted from Okere (1996), compares the regular teaching methodologies frequently used by teachers with the Creativity Teaching Strategy:

Table 17: Comparison of Regular Teaching Methodologies and CTS in Terms of the Roles of the Pupil, Knowledge, Learning, Teaching and Curriculum

	Regular teaching methods	Creativity teaching strategy
Learners	Passive; recipient of knowledge	Active; cognitive; adaptive; purposive; central
Teachers	Active; knowledge dispenser	Team leader; adaptive; partaker in curriculum innovation
Knowledge	Detached; out there; non problematic; fixed	Constructed; problematic; provisional and adaptive
Learning process	An individual process; information to be absorbed	Corporate (social); process knowledge
Teaching	Purely transmission in a classroom situation; not negotiable	Provision of situations; negotiation and interactive
Curriculum	What ought to be taught; rigid KIE curriculum	Flexible; adaptive and programmed activities

(Source: Okere, 1996; pp 76 – 77)

The pretest results also showed that our students are highly restricted when it comes to borrowing ideas from other study areas. The respondents treated physics concepts as distinct from the other science subjects and mathematics. They imagined that physics subject has a set of problems and it provides enough knowledge to tackle the problems independently. The results also showed that presentation of answer to practical questions in diagrams may be difficult amongst students. The reason might be the inability of learners to translate abstract ideas into real images that could be drawn on a paper. Giving the right control variables in an experiment meant that learners were able to at least come up with fair experimental set-ups, which would lead to reliable results. This is an important aspect of creativity that may define the development of the other aspects of creativity. The development of the learners' creative aspect of sensitivity towards a scientific problem was evident; training learners to show sensitivity during scientific investigations should be emphasized in secondary school Physics.

In the course of the study, a number of observations were made and the study would now discuss them. Much of the available literature in education show that a lot of research that has been carried out has mainly focused on the investigation of the processes and situation within the educational systems. A time has now come for the studies to mainly focus on remedying the situation in the educational systems. At the beginning of the study it was noted that the level of scientific creativity in our schools is quite low; other researches have found out that creativity amongst learners is dependent on gender, knowledge and learning opportunities (Ndeke, 2003); it has also been found to be dependant on the content (Okere, 1991). The study made an observation that with time it is possible to remedy the curriculum shortcomings so as to enhance the training of learners in scientific creativity within the educational systems. The study specifically had singled out the factor of the content and investigated how it can be addressed. The modules used were the usual teaching lessons but now enriched with various ideas, situations and problems that require the application of one's creative potential in an attempt to offer a solution to problem. The study hoped that the continued offer of such situation would eventually develop a creative attitude amongst the learners. At the end the study it was observed that the modules were able to achieve the anticipated objectives to a large extent.

A study in creativity had earlier on observed that the age of our school pupils has changed much and the old and comfortable ideas no longer apply. Much will be required of the creative potential of today's school children; therefore we have to search for ways of enabling our learners to realize their full creative potentials. In order to produce creative children, we have to make

changes in our educational systems (Okere & Abuto, 2005). The study therefore observed that schools ought to be places where pupils are trained to think. The school curriculum should provide school pupils with situations that require them to think and apply the products of their thoughts to solve problems within their surroundings. Such thinking should be critical, creative, constructive, independent, logical and analytical. Therefore instead of educational researches focusing on the investigation of learning processes, it should now put more emphasis on the thinking processes. This was the reason why the prepared study modules amply created situations where the thinking processes of the learners would be tested by observing the products of their thinking process.

The study also observed that three things were instrumental when a learning situation is being enriched with creative activities: how a student interprets a scientific problem situation; how such a student approaches the situation in an attempt to offer a solution and finally how the problem solving mechanism of a learner can be improved. When a student is presented with a situation that requires one to devise an experiment to solve a scientific problem, the ability of planning on how to solve the problem was found to be vital. Therefore it is necessary that learners are trained to plan before undertaking any problem solving activities. The first five module lessons were therefore core to the study since they intended to inculcate this skill to the learners. The following key areas were emphasized both in the module teaching and in assessment: The suitability of the design. A designed experiment that is not workable means that the concerned student is not in a position to solve the problem empirically. The modules had therefore to expose the learners to many scientific problems and later on discuss the pooled solutions offered by various groups. The study also laid more emphasis on the project work and practical work in the learners' course book. The study also emphasized on how the learners applied the data they obtained in the solution of the presented problem. Relevant data collected in the process of experimentation suggest that the potential problem solver is in the right track. Learners should therefore be trained in the art of collecting, recording and interpreting data from an experimental situation.

Okere (1996) summarized the skills involved when designing a scientific investigation. They include the following: reformulating general statements in such a way that they are testable; criticizing given experimental procedures so as to give or suggest improvements that should be done on them; devising and describing the sequences of the investigation. This will tell whether the learner can link the stages involved from the first one to the last one. A learner who has internalized the procedure is more likely to apply it in yet another problem being solved.

The CTS was found to elicit positive attitude from both the teachers and the learners; this was during both the piloting stage and in the actual study. The observation here is that teachers and the learners are tired of the regular teaching methods that are rigid and rather deductive in approach; they would therefore appreciate a variation. A comparison for structure of the content of the topic 'energy' as outlined in the learners course book and the one applied in the CTS teaching modules contrast sharply; also the teaching learning activities suggested in the two teaching approaches are not the same; CTS laid more emphasis on learners constructing knowledge, but the regular teaching methods give the general sets of knowledge then outlines the investigative aspects only in experiments to verify or demonstrate the knowledge. This means that in the regular teaching methods, the learners are not exposed to situations that challenge them within their creative abilities, which at the end may promote their scientific creative abilities. This then explained the source of excitement whenever the student were provided with a novel situation and required to solve it creatively. Instead of the learners being required to cram some set of facts, laws and experimental procedures that lead to some data which they fail to interpret adequately and coherently, they were now required to be in charge of the whole process.

CHAPTER 5

SUMMARY, CONCLUSION, IMPLICATIONS AND RECOMMENDATIONS

5.1 Introduction

In this chapter, the study discusses a summary of the results and gives its conclusions based on the findings of its research. It also discusses the implications of such finding to learners, teachers, and policy makers and to the society at large on physics education. The study also gives some recommendations to physics educators based on the research results and also points out areas in which it feels further research should be undertaken.

5.2 Summary

Since the study was to find the effect of CTS on learner's performance and motivation, it is therefore imperative that this chapter should start by discussing the results obtained from the study. The results obtained during the CTS implementation, pretest and post test are discussed. The scores of students in the pretest were quite poor; majority of the respondents scored between 0% and 20% in most of the parts of the questions. Also during marking, learners exhibited inflexibility in the range of responses that they gave. This meant that ordinary secondary school students are not flexible in their thinking skills. The learners were also found to be less fluent in the presentation of their responses since many parts of the questions were mixed up and the scorer had to look for the answers as the scoring process went on. The pre-test results indicated that an average form three physics students is not creative in most of the aspects of creativity tested in the study above.

After the CTS, learners showed that they had improved on some aspects of creativity as evidenced in the results of their post test responses. This was especially in the area of naming control variable. It means that the teaching strategy was able to train learners on how to plan for their experiments. The slow pace of developing the aspects of creativity tested above suggested that learners were not used to such training; also naming sources of error required a critical mind that was able to carry out a thorough and conclusive analysis of the experiment. This meant that our students should be trained in higher thinking skills such as analysis and synthesis. More practical working should therefore be involved in the course of their study and learners trained on how to criticize their experiments by identifying possible sources of error. Two thirds of

the responds wouldn't give a single workable method of solving the problem and even those who gave a workable method were unable to give the correct control variables and sources of error. Another factor that might have influenced the development of the aspects of creativity worth to be mentioned here though not related to the objectives of the study was the individual differences of the inducted teachers towards work or their instructional output consentience and interest. The teacher who appeared more interested in the instructional strategy surprisingly had his group realize a great improvement in the post test results over the pretest. We can generally put it that the usual teaching strategies could develop some aspects of creativity amongst learners; but the creativity instructional strategy as seen from the above results would enhance the development of such aspects especially the aspects of planning and sensitivity.

5.3 Conclusion

Lack of creative skills amongst our KCSE graduates is very unfortunate, creativity in itself is a lifelong skills and possessing it opens wide the individuals conceptualization of scientific problems and their solutions. It also helps an individual to remove conceptual blocks in the problem solving process. As it had been noted in earlier studies that the low performance in the scientific creative skills is partly due to lack of practice on such skills, the result of this study supported the same sentiments in that the performance of the control group that was never trained through Creativity Teaching Strategy did not improve alongside the other groups that were trained in the strategy. The study therefore came up with a conclusion that through teaching, learners could be trained to be more creative; Guilford had said many years ago that creativity represented to some extent many learnt skills which through training can be extended within limitation. Creativity can therefore be taught to secondary school Physics students as a skill and as an ability. More effort has to be made to ensure that appropriate teaching strategies such as concepts mapping and creativity are incorporated in the educational systems to improve on learners' creative ability.

Since the study followed the normal teaching organization in order for it to be successful and make its findings authentic, the results obtained may be taken to be binding. The teaching materials used were prepared with a lot of consultations, assignments and work sheets were used frequently, the learning tasks were arranged in sequences, summary and pooled results were handed over to the learners to check on areas they need to improve on. Finally achievement tests that were meant to check on the change in their abilities after the training were given to the

learners. Unlike in the usual text book assignment–recitation scheme of teaching which has a lot of limitations, CTS gave learners a chance of being at the centre of the process of knowledge construction. And just like in the other inductive teaching methodologies, the CTS guided the pupil's mind in a sequential movement from concrete experiences to the development of some general concepts.

5.4 Implications of the Study

The results of the study implied that learners could be trained to be creative. Also, judging from teachers and learners views on the strategy, it is a teaching method that is more exciting to both teachers and learner which work towards a common goal of improved performance in the learners creative abilities. In this strategy, learners are trained not to view their physics teachers as knowledge dispenser, but to view them as a 'knowledgeable other'. The CTS also brought teachers close to their Physics students especially when they moved amongst the groups during which learners would ask questions freely to the teacher as a guide towards the knowledge creation. The findings of this study, just like the findings of the earlier researches, found out that when learners are involved in the knowledge construction, they learn meaningfully and the knowledge so acquired becomes firmly in grained in the brain than the one they get through cramming. The results of the study addressed itself to the physics teachers and policy makers; it is not sufficient to talk about learners development of creative skills, creativity can be taught to learners by varying the modes of stimuli provided in the learning environment. The CTS also influenced learners' motivation (interest) in the topic.

Apart from being effective in promoting learners performance, it also improved their interest in the study. This was evident from the learners' reaction after learning the topic 'energy' following the strategy. Quite a number of them agreed that CTS enabled them to draw mental images and put them on the paper while answering the question. Therefore the Creativity Teaching Strategy should be considered as one of the possible teaching strategies that physics teachers should be challenged to incorporate in their daily teaching activities.

As already highlighted in the literature review, there's a need to train our learners to be creative; this is what the study would like to pass across not only to the physics educators but also to all school teachers regardless of their area of specialization. The study would like to re-emphasis to physics teachers why they should invest in teaching for creativity:

teaching for creativity inculcates three main abilities that a learner needs to gain in the course of their study; these abilities include the following: synthetic ability, analytic ability and the practical ability. Synthetic ability involves the widening of the abilities of a learner in order to enable such a learner to think divergently and generate many and new novel and interesting solutions and suggestions to a scientific problem. This ability also enables a learner to make spontaneous connections between ideas or groups of things which is not obvious to an average mind. In the analytic ability, the learner acquires critical thinking and appraisal as one is faced with a novel scientific problem and required to offer solution (Sternberg, 1996, pp 679).

Creative persons should be able to consider implications, limitations, problems, outcomes and possible responses for their suggestions. In the practical ability, which is based on the everyday experiences, creativity training is not just able to train learners to identify problems and offer possible solutions but also to apply the solutions in their daily life. Therefore one is able to communicate such ideas logically and show its usefulness and ones innovativeness. This is an important aspect not only in science education but also in other domains of knowledge. The physics teachers who took part in the study both at the pilot and research stage gave positive recommendations on the viability of the teaching strategies amongst secondary schools students. The teachers were positive about the attitude of expectations that their students exhibited as they took part in the physics lessons. The modules ensured that learners and teachers were fully preoccupied during the lessons, the teacher's role being reduced to that one of a 'knowledgeable other' rather than that of a 'knowledge dispenser'.

5.5 Recommendations for Stakeholders

The study recommended that physics teachers be trained to teach following this strategy since it has been found to elicit the development of creative abilities amongst the learners; it echoes the sentiments made in an earlier research that had challenged the school curriculum and practices in the following way '....teacher education programmes should make teachers familiar with the philosophy of creativity for science educationthis will help teachers to develop creative potentials of their learner... the education curriculum objectives should include or reflect creative abilities and suggest how they should be evaluated. Teaching strategies that foster creativity should be included in the curriculum

so that teachers can practice and master them; this will enable teachers to create learning opportunities that will improve creative abilities amongst the learners. In service training for teachers on meaning and measures of creativity in science education should be adopted ...' Creativity teaching strategy to secondary school physics students would be a step forward towards the achievement of the above recommendation. The study recommends that secondary school physics teachers should be trained in the creativity teaching strategy which will not only be beneficial to the learners themselves but also to the teachers. The creativity teaching strategy should not be limited to physics education but it should also be practiced across all the other science subject areas.

5.6 Recommendations for Further Research:

In the course of the study, various issues that could have also come into play and influenced learners' acquisition of creative abilities were encountered. The study wishes to suggest that further research be conducted to look into such issues. Such areas include the following:

- i) The influence of creativity on learner performance and motivation in secondary school mathematics education.
- ii) The influence of school category on learner performance in creativity in secondary school physics education.
- iii) The influence of creative training strategies on learners' fluency.
- iv) The influence of creativity teaching strategy on the performance and motivation of learners in physics practical.
- v) The influence of creativity teaching strategies on learners' development of higher thinking skills (application and analysis).

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Appendix A

Creativity Instructional Modules for the Topic 'Energy'

Instructional modules to incorporate creativity in teaching the topic 'Energy' among form three students

Research has shown that there is lack of creative ability among secondary school students. The students score very low on problems that require them to exhibit scientific creative skills in solving problems in their daily life experiences (Okere, 1986). This problem has been partly blamed on teachers who do not give sufficient practice to their students. These creativity modules have been specifically prepared to help learners build up their scientific creative skills. They are also intended to help a Physics teacher learn how to incorporate creative activities in his/her daily teaching activities. The modules basically consist of practical lessons in the topic 'energy' which are enriched with situations where learners are expected to outline expected experimental procedures for investigations, criticize given experimental procedures (by suggesting sources of errors) and also giving alternative experimental set ups.

The discussion parts of the modules require learners to think in abstract and create the given situation and then describe it. The modules are prepared based on Okere's model of creativity measures in science education (Okere, 1986). It is my hope that the modules would be easy to follow and may achieve the intended objectives. The modules are intended to supplement teacher's notes that are used in the classroom in order for the teachers to inculcate creativity in the course of the lessons.

Energy: Introduction:

All living things need energy. Machines also need energy. Energy is required to do work. Energy is therefore defined as the capacity to do work. The S.I unit of energy and work is the Joule (J). Energy exists in many forms, which include the following:

- Mechanical energy
- Chemical energy
- Thermal energy

- Sound energy
- Light energy
- Electrical energy

Mechanical Energy:

Mechanical energy can be divided into two categories -potential and kinetic energy

Potential Energy (P.E)

This is the form of energy stored in a body due to its particular state or position. Bodies that are able to fall down have stored energy called gravitational potential energy. This is the energy possessed by falling water in a waterfall, falling hammer and an object falling down from up in the air. The gravitational potential energy of a body depends on factors such as:

- a) The position of the object above the ground.
- b) The mass of the object.
- c) The gravitational field strength.

Experiment 1.1: To Investigate Factors That Influences The Gravitational Potential Energy of a Raised Body:

Objects at different heights above the surface possess different amounts of gravitational potential energy. This is why an object thrown very far up in the air falls down with a lot of 'energy' than an object thrown just a short distance up in the air.

Experiment 1.1a

In this experiment, you are provided with the following items: several masses of different weight, a metre- rule; you are required to find out how the gravitational potential energy of a body changes as the height of the body changes above the bench:

- a) Describe the experimental procedure you will carry out to solve the problem, if need be, use diagrams.
- b) In your experimental procedure, what do you need to hold constant (control) in order to observe how the gravitational potential energy of an object changes with height above the ground? Name at least five things you will need to control.
- c) State and explain how you will be able to measure the 'amount' of gravitational

potential energy of the falling object in this experiment. Give at least four ways.

- d) State three other things, apart from careless mistakes, that may prevent you from obtaining the right conclusion.

Experiment 1.1b

Using the above items provided in experiment 1.1 a, explain how you can use them to show that the gravitational potential energy depends on the mass of the object.

- a) In this case, what factors are you holding constant? Name at least four of them.
- b) Also state other things apart from careless mistakes that may cause errors in your results
- c) Apart from careless mistakes, explain how sources of errors can be avoided or corrected in such an experiment.

Lesson 3

To Investigate the Elastic Potential Energy (Strain Energy) of a Spring.

Elastic potential energy is due to strain i.e. stretching or compressing state. An object that is either stretched or compressed possesses elastic potential (strain) energy. This is the energy found in a compressed spring or in a stretched elastic band.

When a spring is stretched it gains elastic potential energy and this is why when it is released, it 'springs' back i.e. it can do some work (observe this by stretching an elastic band or a spiral spring).

Experiment 1.2: To Find The Work Done in Stretching a Spring:

You are provided with some masses, spiral springs a mm-scale or metre rule and a retort stand with a clamp. You are required to assemble your apparatus as shown below so that you may find the work done when a spiral spring is stretched.

Assemble the apparatus (as shown below) and carry out the experiment and fill your results in the table below:

Mass (g)	$F = \text{weight (N)} = Mg$	Extension, cm
0		
20		
40		
60		
80		
100		
120		

Finally, plot a graph of force (N) - y-axis, against extension (cm) and find the area under the graph. Notice that the area under the graph is given by force (N) X length (cm). Force (N) X distance (M) gives work done. Therefore the area under the graph will give the work done (i.e. energy stored) when the spring was stretched to the length shown.

- Name two precautions that you need to take care of when assembling the apparatus;
- Name four things that should remain constant (i.e. unchanged) from the beginning to the end of the experiment;
- What other things, apart from careless mistakes, will lead to obtaining wrong results;
- The arrangement of the experiment can be changed so as to obtain more accurate results. Suggest some changes that you think can lead to improved results;
- Apart from using the graph to find the work done on stretching the spring, suggest three other possible ways of obtaining work done on stretching a spring;
- If I were to repeat the same experiment using a spring of the same diameter but made from different materials, explain the differences I will obtain in my final results.

Lesson 4 and 5

Objectives: learners should be able to:

- Describe an experimental set up to investigate factors that affect the kinetic energy content of a body.
- Give some sources of error that could have influenced the accuracy of their results.

Kinetic Energy:

It's the energy possessed by a body due to its state of motion. Learners should give many

examples to illustrate this, for example:

- i) A flying stone can cause damage while a stationary one will not.
- ii) A falling hammer drives a nail into wood.
- iii) When a moving object collides with a stationary object, the stationary object is forced to move.

Learners should be challenged to investigate factors that kinetic energy depends on -both mass and velocity. For example:

- a) A heavy hammer drives a nail faster than a lighter one;
- b) A tennis ball flying very fast can break a windowpane, while a slow one will not.

Learners can then be involved in the following discussion:

- i) Give at least three situations where kinetic energy is
 - a) Useful to man
 - b) Harmful to man
 - ii) Give some factors that reduce the amount of kinetic energy possessed by a moving body,
 - iii) Two objects, coming from opposite directions collide and their motions stop.
- Explain what has happened to their kinetic energy.

Lesson 6:

Chemical Energy: It's a form of store energy. It is stored through a chemical reaction.

Example includes energy stored in food, fossil fuel (e.g. coal, petrol, oil, and natural gas), cells, and batteries.

This energy is released through a chemical reaction.

Activities/discussions: comparing the amount of chemical energy possessed by paraffin and laboratory gas. A student one day gave a general statement that 'Laboratory gas contains more chemical energy'

- i) Criticize the above statement,
- ii) Modify it so that it is possible to come up with an experiment in the laboratory to confirm the statement.
- iii) In such an experiment, what are the sources of error that will prevent you from obtaining accurate results?

Lesson 7:

Objectives: learners should be able to:

- a) Device an experiment to illustrate that sound and light are forms of energy.
- b) Give other alternative experiments that can be used.
- c) Criticize such experiments by giving their sources of error.

Sound and Light Energy

Sound energy: this is energy due to mechanical vibration.

Light energy: it is due to the movement of an electron from one energy level to another in an atom

Activities/ Discussion:

- a) Try to device an experiment to show that sound is a form of energy.
- b) Light energy (especially from the sun) is the source of all the chemical energy stored in fossil fuel and foods. Discuss this statement.
 - Explain many uses to which light energy can be put into.
 - Device an experiment to demonstrate that light is a form of energy. Name two other alternative experiments that can be used to illustrate the same.

Lesson 8 and 9: Heat energy

Heat is the energy transferred from one place to another owing to a temperature difference between them. The quantity of heat transferred between two bodies/places in contact depends on three main factors:

- i) The mass of the substance receiving heat
- ii) The type of the material receiving heat
- iii) The temperature different

Experiment 1.5 (a): to investigate the relationship between quantity of heat Transferred and Mass of Substance Heated:

You are provided with a burner, tripod stand and gauze, 250cm³ beakers, thermometers, stop watch, measuring cylinder, beam balance and water. You are required to investigate whether heat energy transferred from the burner to the water depends on the mass of water heated.

- a) Describe an experiment you will carry out to investigate the problem. Use diagrams

where necessary.

- b) Name five things that you will hold constant during the experiment.
- c) Your heat transfer from the burner to water was not 100% efficient. What caused heat to be lost between the burner and water?
- d) How would you improve the heating so that heat transfer is more efficient? Give as many ways as possible.

Experiment 1.5 (b): To Investigate How Quantity of Heat Transferred Depends on the Change in Temperature Achieved.

Using the above apparatus provided, carry out an experiment to investigate the above scientific problem.

- a) Describe the procedure that you are going to follow to investigate the problem. Make it very clear that another person can follow it and obtain similar result.
- b) In this case, what variable (things) are you holding constant? (Give at least five such variables)
- c) Name the problems or things that might make you not to get the right answer. For each problem stated, give a way of solving it.

Lesson 10

Experiment 1.5 (c): To Investigate the Dependence of the Quantity of Heat Supplied on the Type of the Substance Being Heated:

You are provided with thermometer, stop watch, burner, tripod stand and gauze, three beakers, weighing balance, water, paraffin and glycerin in different containers. You are required to find out whether the amount of heat transferred from the burner to each one of the types of liquids depends on their nature.

- a) Think of the experimental procedures you will carry out to investigate this. Describe the experimental procedure clearly so as somebody else may follow it and obtain a conclusion.
- b) In your procedure, identify at least three things you are maintaining constant for you to obtain clear results.
- c) Your results were affected by some factors so that they were not very accurate. Identify at least three of such factors.

- d) Give four ways in which the experiment procedures may be modified so that better results can be obtained.
- e) Think of two other ways of carrying out the experiment apart from the one you have outlined above.

Lesson 11

Objectives: learners should be able to:

- a. Device an experiment to illustrate the conversion of energy from one form to another.
- b. Criticize such an experiment by giving sources of error that may influence results.

Energy Transformation

‘Energy can neither be created nor destroyed; it can only be converted from one form to another’; give situations to justify this statement.

Experiment 1.6 (a): Hammering a Nail:

Learners should identify the type of energy possessed by the hammer at various positions, and also the conversion (transformation) of energy from one form to another. At each transformation process, they should also identify a transducer.

- a) Learners should give alternative experiment to the one outlined above.
- b) What factors will make such an experiment not to be effective in demonstrating energy transformation?

Experiment 1.6 (b): Energy Transformation When a Touch Bulb Lights

Learners should trace the energy transformation from the battery/cell till the bulb lights. They should also attempt tracing the energy transformation (when the bulb lights due to electricity/ electric energy) from H.E.P. or geothermal power energy. How can energy transformations be made more efficient in the above cases? Let learners think of transducers at each stage of energy transformation.

Experiment 1.6 (c): Energy Transformation When a Mortar is Turned by Electricity to Cut Wood:

Learners should be able to trace energy transformation from when falling water produces electricity to the point where mortar turns the saw to cut wood. At each stage of transformation, they should identify a transducer.

- a) Explain why it is difficult to achieve a 100% efficient energy transfer
- b) How should energy transformed be made more efficient at each level?
- c) Give one more alternative example to illustrate the same energy transformation.

Lesson 12

Objectives: learners should be able to:

- 1) Device an experiment to illustrate the conversion of energy from one form to another;
- 2) Criticize such an experiment by giving sources of error that may influence results.

Sources of Energy:

Sources of energy are classified into renewable and non-renewable source of energy

Renewable resources: They are sources of energy that can be replaced fairly fast. Their examples include the following: Solar, Geothermal, Biogas, tidal energy, Biomass, wind and water.

Discussion 1: Imagine you woke up one morning and there was no sunlight.

- a) Discuss the various things that will go wrong. In your discussion, give illustration of all the benefits we get from sunlight.
- b) Imagine you are asked to suggest ways of remedying (solving) the above problem, give as many ways as possible of solving the crisis.

Appendix B-1

The Pre-test

A marble was dropped into a tall cylinder containing some liquid. A student observed that the marble moved very slowly through the liquid to settle at the bottom of the cylinder. This means that the marble required a lot of energy to move through the liquid.

The student would like to find out if the amount of energy a marble requires to move through a liquid depends on the type of the liquid (for example water, glycerin and paraffin)

Describe an experiment the student could do to test this. It might help you make your plan if you think about:

- 1) The things the student should use (you can draw a diagram to clarify the experiment set up)
- 2) The things the student should measure
- 3) How the student should measure them
- 4) How the student should work out the results
- 5) What the student should do to ensure that accurate results are obtained
- 6) What other factors (apart from careless mistakes) are most likely to make the students results unreliable? Make your plan as clearly as possible so that someone else could follow it.

Appendix B-2

The Post- test

When an object is dropped on a spiral spring held upright on a table, it bounces upwards after hitting the spring to a height which depends on the amount of work done on the spring by the falling object. A student would like to find out if the amount of work done on the spring depends on the type of the material from which the spring is made (for example whether it is made from copper, steel or nichrome)

Describe an experiment the student could do to test this. It might help you make your plan if you think about:

- 1) The things the student should use (you can draw a diagram to clarify the experiment set up)
- 2) The things the student should measure
- 3) How the student should measure them
- 4) How the student should work out the results
- 5) What the student should do to ensure that accurate results are obtained
- 6) What other factors (apart from careless mistakes) are most likely to make the students results unreliable? Make your plan as clearly as possible so that someone else could follow it.

Appendix B-3

The PSAQ Questionnaire

The following statements concern how you find Physics subject and learning Physics in general. You are required to answer the questions by placing a tick (✓) on the space that carries the best choice that reflects your feelings towards the statement. Each statement has five (5) choices and you are kindly requested to select only one of the choices. Use the key shown below to help you select your choice:

SA - Strongly Agreed

UN - Undecided

D- Disagreed

A - Agreed

SD - Strongly Disagreed

NO	ITEM	SA	A	UN	D	SD
1	I often look forward towards physics lessons					
2	I enjoy learning physics lessons					
3	I regularly revise my physics notes					
4	I practice solving physics problems on my own					
5	I often ask questions during a physics lesson.					
6	Physics knowledge relate to my daily life					
7	I feel there is need for me to continue studying Physics					
8	I do understand what physics is all about					
9	My success in physics is very important					
10	I hope to pursue a physics career beyond my form Four level					
11	I feel confident during physics lesson					
12	I put into practice what I learn in physics in my daily life experience					
13	I do expect to perform well in physics after an examination					
14	I always manage to solve physics problems on my own					
15	I do perform well in physics					
16	I am satisfied with the way I am taught physics					
17	Our teacher is encouraging during physics lessons					
18	Learning physics is rewarding in real life					
19	I always manage to connect experimental set-up in physics practical					
20	I feel relaxed during a physics lesson					

APPENDIX B-4

Scoring criteria for the pre test instrument: appendix B-1 ('Marble')

1. The things the student should use:

- a) 3 marbles
- b) 3 cylinders
- c) Watch clock
- d) Metre rule
- e) Beam or top pan balance
- f) Water
- g) Glycerin
- h) Paraffin
- i) Elastic band/marker/sticker
- j) Vernier caliper/micrometer screw gauge
- k) Work bench/rigid support/firm frame

Experimental set up for the apparatus:

2. The things the student should measure:

- a) Mass of marble
- b) Height of liquid column in tall cylinders
- c) Time taken by marble to reach the lower marked points
- d) Height of marble or hand above the liquid in tall cylinder
- e) Volume of liquids
- f) Diameter of marble
- g) Diameter of tall cylinders
- H) Distance between the two elastic bands (labeled '1')

3. How the student should measure them

- a) Mass: use a weighing balance
- b) Time: use a stop watch/clock/timer
- c) Height: use a metre rule

- d) Volume: use a measuring cylinder/volumetric flask/graduated beaker
- e) Diameter of marble: micrometer screw gauge/vernier caliper
- f) Diameter of cylinder: vernier caliper/metre rule
- g) Height above liquid level: metre rule
- h) Distance 'l': metre rule

4. How the student should work out the results

- a) velocity of the marble in the liquid: the higher the speed the less the amount of energy expended in overcoming viscous drag, but the lower the speed of marble the higher the viscous drag in the liquid, and thus the more the amount of energy expended.
- b) Observing visually which marble is doing a lot of work to move to the bottom. A slow marble must apparently do more work to overcome opposing forces on its motion

5. What the student should do to ensure accurate results are obtained

- a) Ensure the marbles are of the same size and mass. Preferably use the same marble in each case
- b) Ensure the tall cylinders are of the same diameter and height. Preferably use the same cylinder in each case
- c) Ensure same volume or height of liquid is taken in each case
- d) Ensure the marble is dropped from the same height above the liquid surface in each case
- e) Use timers with the same precision
- f) Same person to conduct the experiment in each case
- g) Conduct the experiment severally and take average values
- h) Ensure the tall cylinders are transparent and clear
- i) Ensure the work bench is firm does not wobble and disorganize the experiment

6. What factors are most likely to make the results unreliable?

- a) Conducting the experiment in a hurry, lack of seriousness or keenness
- b) Conducting the experiment only once instead of several times and taking an average value

- c) Lack of precision in measurements
- d) Conducting an experiment as a group instead of one person conducting it to the end.
- e) Use of non standard liquids and apparatuses
- f) Misinterpretation of the tasks and procedures

Scoring criteria for the post test instrument: appendix B-2 ('springs')

1. The things the student should use

- a) 3 springs: one made of copper, steel, and the other nichrome
- b) A metre rule
- c) A 50g mass
- d) A vernier calipers or micrometer screw gauge
- e) A strong card board or firm wall or barrier
- f) Marker/pen/pointer
- g) Work bench/a firm support

Experimental set up for the apparatus

2. The things the student should measure

- a) Length of the springs
- b) Diameter of the springs
- c) Thickness of the wire from which each of the spring is made from
- d) The height at which the mass is dropped on the spring
- e) The height to which the mass is rebounded by the spring
- f) The mass of the object dropped on the spring

How the student should measure them

- a) The height of rebound: use a metre rule
- b) Mass of object: use a beam or top pan balance
- c) Diameter of wire: use a micrometer screw gauge /vernier calipers
- d) Diameter and height of the spring: use a 30-cm rule
- e) Height of the object above the spring: use a metre rule

4. How the student should work out the results

- a) Measure the height of rebound: the higher the height, the more the amount of work done on the spring by the falling object
- b) Measure the amount of the compression on each spring due to the falling object.
Big compression means a lot of work done on the spring

5. What the student should do to ensure that more accurate results are obtained

- a) Ensure that the springs are of the same diameter, height and made from wires of the same thickness
- b) Springs used should have the same number of turns
- c) Springs should be placed at the same position in each case
- d) Experiments should be repeated severally with masses dropped from varying heights for comparison
- e) Springs should be made from new wires preferably in each case
- f) Masses should be dropped from the same height in each case
- g) Same rule should be used to record the lengths
- h) Same mass to be used in each case
- i) Same person to complete an experiment
- j) Mass should be centrally aligned to the spring before dropping so that it is rebounded vertically upwards
- k) Different students to perform comparison experiments

6. The things likely to make the results unreliable

- a) Use of old and rusty wires to coil the springs
- b) Mass not properly aligned with the spring it can be rebounded sideways
- c) Use of springs with differing dimensions – either diameter or height or both
- d) Use of springs or masses whose bases are not uniformly flat
- e) Lack of precision in making readings or during recording and interpretation of measurements
- f) Not repeating the experiment severally and taking average values
- g) Several students conducting an experiment
- h) Masses dropped from varying heights above the springs

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28th August 2008

Samuel K. Hungi
Egerton University
P.O. Box 536
NJORO

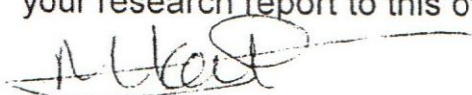
RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on, *'Influence of Creativity Teaching Approach on Students Performance and Motivation in the topic "Energy" in Secondary Schools Physics in Nakuru District,*

I am pleased to inform you that you have been authorized to carry out research Nakuru and Laikipia West Districts for a period ending 31st December, 2008.

You are advised to report to the District Commissioners, the District Education Officers Nakuru and Laikipia Districts before embarking on your research.

On completion of your research, you are expected to submit two copies of your research report to this office.



M. GATOBU
FOR: PERMANENT SECRETARY
Copy to:

The District Commissioner
Nakuru District
Laikipia District

The District Education Officer
Nakuru District
Laikipia District

EGERTON

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OFFICE OF THE DIRECTOR GRADUATE SCHOOL

Ref: EM14/1239/04

Date: August 28, 2007

The Permanent Secretary,
Ministry of Education, Science and Technology,
P. O. Box 30040,
NAIROBI.

Dear Sir,

RE: RESEARCH PERMIT – SAMUEL K. HUNGI REG. NO. EM14/1239/04

This is to introduce and confirm to you the above named student in the Department of Curriculum Instruction & Educational Management, Faculty of Education and Community Studies.

He is a bonafide registered M.Ed. student in this University. His research topic is entitled "Influence of Creativity Teaching Approach on Students' Performance and Motivation in the Topic "Energy" in Secondary School Physics in Nakuru District, Kenya"

He is at the stage of collecting field data. Please issue him with a research permit to enable him undertake the studies.

Yours faithfully,

J.K.K. Biwott

Assistant Registrar

For: DIRECTOR, BOARD OF POSTGRADUATE STUDIES

c.c.	Prof. M.I. Okere	– Supervisor
	Dr. J.M. Changeiywo	- Supervisor

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NAKURU DISTRICT
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NAKURU

Ref. NKU/ED/156159

29th August, 2007

All Principals
Nakuru District.

RESEARCH AUTHORISATION **SAMWEL K. HUNGI REG. NO. EM.14/1239/04**

The above named is an MED student at Egerton University he is at the stage of conducting research on Nakuru District, Secondary schools on the topic, "Influence of creativity teaching approach on students performance and motivation in a physics topic "Energy"

He has authority of this office to collect data from your schools assist him as this is part required for the Masters in Education degree.

PP

J. A. Adero

For: DISTRICT EDUCATION OFFICER

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