INFLUENCE OF SECONDARY SCHOOL STUDENTS' GENDER, ACADEMIC ACHIEVEMENT AND CHEMISTRY SELF-CONCEPT ON SCIENTIFIC CREATIVITY IN CHEMISTY EDUCATION IN NAIROBI, MURANGA, KIAMBU AND KAJIADO COUNTIES

FLORENCE WANJA KAMONJO

A Thesis Submitted to the Board of Postgraduate Studies in Partial Fulfilment of the Requirements for the Award of the Degree of Doctor of Philosophy in Science Education of Egerton University

EGERTON UNIVERSITY

MARCH, 2016

DECLARATION AND RECOMMENDATION

Declaration

This thesis is my original work and has not been presented for a degree or any other award in this or any other university

Signature ___________________________ Date _______________

Florence Wanja Kamonjo

Reg. No. ED13/ O334/ 12

Recommendations

This thesis has been submitted with our recommendation as the University Supervisors.

Signature ___________________________ Date _______________

Prof. Samuel W. Wachanga,

Professor of Chemistry Education,

Faculty of Education and Community Studies,

Department of Curriculum, Instruction & Educational Management,

Egerton University

Signature ___________________________ Date _______________

Prof. Mark Okere,

Professor of Chemistry Education,

Faculty of Education and Community Studies,

Department of Curriculum, Instruction & Educational Management,

Egerton University

DEDICATION

This thesis is dedicated to my mother the late MARGARET WAMBUI KIMANI for her perseverance and sacrifice so that I could get education.

ACKNOWLEDGEMENTS

I am grateful to the Ministry of Education Science and Technology (MOEST), for granting me permission to undertake this study. My gratitude also goes to the County Directors of Education and District commissioners of the counties involved in this study for allowing me to conduct the study in schools in the counties. I would like to sincerely thank my supervisors; Professor Mark Okere and Professor Samuel Wachanga who jointly supervised the preparation and the writing of this work. I am grateful for their supervision, guidance, encouragement and their patience without which this study would not have been a reality. Their constructive suggestions made this research an invariable professional experience. May the good Lord bless them for their inputs. My sincere thanks also go to the principals of all the secondary schools, heads of science departments, heads of chemistry subject and examination officers for the support and cooperation they accorded me during the study. I am also indebted to Madam Ann Awino, Principal Tumaini House School for her support and encouragement throughout the study. Am also indebted to my colleagues and friends Jane Mihindo, Alice Omondi, Catherine Ndeke and Joseph Mwangi for the invariable support they accorded me throughout the study. I also acknowledge their prayers, encouragement, understanding, cooperation, material and moral support of my family members – spouse Mr Kamonjo Kiburi, Son Kepha Kimani and daughters Mary Wambui and Stacey Waithera. I am greatly indebted to you all. Above all am grateful to the Almighty God without whose help I would not have accomplished anything in this study. To God is all the glory forever.

ABSTRACT

Education is the most critical ingredient in a country's development process in the social, economic and political realms. Kenya in its vision 2030 hopes to be transformed into a newly- industrialised, middle-income country providing a high quality of life to all its citizens in a clean and secure environment by the year 2030.To realise this vision, the country needs to develop through its education system, manpower that is trained to think creatively. The role of Chemistry in the development of the scientific base of a country cannot be over emphasized and Kenya is no exception. Kenya's secondary school chemistry, physics and biology syllabi recommend the acquisition of creative skills by students. Few studies have been carried out in Kenya with regard to scientific creativity in secondary schools. Studies in Physics and Biology have shown that the level of scientific creativity is low and is influenced by such factors as gender and knowledge. If creativity skills in science education amongst secondary school students remain low, it will be difficult for Kenya to become industrialised by the year 2030. It is not clear whether the low levels of scientific creativity found in Biology and Physics also apply to chemistry hence, there was need to determine the level of scientific creativity in chemistry and factors influencing it. Therefore, the purpose of this study was to examine whether learner's chemistry self-concept, academic achievement, and gender influence the level of scientific creativity in secondary school chemistry. The study involved Ex Post Facto research with causal-comparative and correlational designs. The target population was secondary school students in Nairobi, Muranga, Kiambu and Kajiado counties in Kenya. The accessible population of the study was all Form Three students in National Secondary Schools in Nairobi and Kiambu Counties and all Form Three students in County Secondary Schools in Muranga and Kajiado Counties in Kenya. A sample of 16 schools (4 Boy's and 4 Girl's National schools and 4 Boy's and 4 Girl's District schools)} were involved in this study. National schools were selected through random sampling, while the county schools' selection was through purposive random sampling. Participating Form Three streams (classes) in the schools were selected through stratified random sampling. A total of 672 students, (398 boys and 274 girls) were involved in the study. Data were collected using three instruments; the Chemistry Achievement Test (CAT), the Chemistry Scientific Creativity Test (CSCT) and Chemistry Self-Concept Questionnaire (CSCQ). The test items were piloted in two schools; a National and a County school in Nakuru County. Quantitative data from CAT and CSCT were analysed using Pearson Product Moment Correlation Coefficient and t-test. Tests of significance were done at 0.05 alpha level. Multiple regressions were also used. The findings of this study indicated that the level of scientific creativity in chemistry education is low. Scientific creativity level was found to be influenced positively by learners' chemistry self-concept and academic achievement. The findings further indicate that the level of scientific creativity in chemistry was not gender dependent. The results of the study are likely to be helpful to secondary school chemistry teachers as they seek to enhance creativity in students. In addition, the results may be useful to chemistry curriculum developers in Kenya as they seek to enhance scientific creativity in chemistry education in secondary schools.

TABLE OF CONTENTS

DECLARATION AND RECOMMENDATION-- ii
COPYRIGHT-- iii
DEDICATION--- iv
ACKNOWLEDGEMENTS-- v
ABSTRACT--- vi
TABLE OF CONTENTS--- vii
LIST OF TABLES--- xi
LIST OF ABBREVIATIONS & ACRONYMS -- xv
CHAPTER ONE -- 1
INTRODUCTION -- 1
1.1 Background to the Study --- 1
1.2 Statement of the Problem -- 7
1.3 The Purpose of the Study -- 8
1.4 Objectives -- 8
1.5 Hypotheses--- 9
1.6 Significance of the Study --- 9
1.7 Scope of the Study---10
1.8 Limitation of the Study ---10
1.10 Operational Definitions of Terms--11
CHAPTER TWO -- 13
LITERATURE REVIEW -- 13
2.1 Introduction---13
2.2 Definitions of Creativity--13
2.3 Self-Concept---14
2.4 Chemistry Self- Concept--16
2.5 Creativity and Self- Concept ---17
2.6 Creativity and Academic Achievement---19
2.7 Creativity and Gender ---21
2.8 Scientific Creativity --23
2.9 Measurement of Creativity ---24
2.10 Meanings of General Creativity--27
2.11 Meanings of Creativity that have Relevance to Science Education-----------------27

2.11.1 Sensitivity to Problems--27
a. Reformulating General Statements --28
b. Criticizing Experimental Procedure ---28
c. Describing the Sequences of Investigation ---28
d. Devising and Describing Investigations ---28
2.11.2 Recognition of Relationships---29
A. Selecting a Correct Hypothesis from Given Alternatives -----------------------------------29
B. Generating a Hypothesis from a Particular Topic Area--------------------------------------29
C. Generating a Hypothesis from Many Topic Areas ---29
2.11.3 Flexibility in Reasoning--29
2.11.4 Planning for Scientific Investigations---30
I. Reformulating General Statements --30
II. Criticising Experimental Procedures --30
III. Describing the Sequences of Investigation --30
2.12. Theoretical Framework --31
2.13 Conceptual Framework---33
CHAPTER THREE ---35
RESEARCH METHODOLOGY---35
3.1 Introduction---35
3.2 Research Design --35
3.3 The Target Population and Accessible Population---36
3.4 Sample Size--36
3.5 Sampling Procedure ---36
3.5.1 Selection of Participating Schools ---36
3.5.2 Selection of Participating Stream --37
3.6 Instrumentation---37
3.6.1.1 Validation of the CAT Items ---37
3.6.1.2 Reliability of CAT --37
3.6.1.3 Item Analysis of CAT --38
3.6.2. Chemistry Scientific Creativity Test (CSCT)--43
Validation of the CSCT Items --43
Reliability of CSCT --43
Item Analysis of CSCT--44
3.6.3 Chemistry Self-Concept Questionnaire (CSCQ)--44

3.7 Data Collection Procedure--45
3.9 Data Analysis---46
CHAPTER FOUR ---48
RESULTS AND DISCUSSION ---48
4.1 Introduction ---48
4.2 Chemistry Scientific Creativity Test (CSCT)--48
4.2.1 Introduction--48
4.2.2 Students' Responses and Performance on the (CSCT)---------------------------------------48
4.2.2.1 Planning Aspect ---48
4.2.2.2 Recognition of Relationships Aspect of Scientific Creativity ----------------------------62
4.2.2.3 Flexibility Aspect ---72
4.2.2.4 Sensitivity Aspect ---76
4.3 Means and Standard Deviation by Gender on the Four Aspects of Scientific Creativity and Overall Scientific Creativity Test --82
4.4 Discussion of the Results --87
4.5.0 Creativity Level in Chemistry ---88
4.5.1 Level of Scientific Creativity by Gender. --89
4.6 Difference in Performance in Chemistry Scientific Creativity Test by Gender ------------91
4.6 Discussion of Results--92
4.7 The Relationship between Scientific Creativity in Chemistry and Academic Achievement in Chemistry--93
4.8 Discussion of Results--94
4.9. Relationship between Students' Chemistry Self-Concept and Scientific Creativity in Chemistry Education. ---95
4.10 Discussion of Results --96
4.11 Multiple Regression involving Scientific Creativity as Dependent variable and Students Self-Concept and Academic Achievement as Predictors. ---------------------------------------96
4.12 Discussion of Results -- 102
CHAPTER FIVE-- 104
SUMMARY, CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS --- 104
5.2 Summary of the Major Findings. -- 104
5.3 Conclusions -- 105
5.4 Implication of the Findings--- 105
5.5 Recommendations of the Study-- 106

5.6 Suggestions for Further Research -- 107
REFERENCES --- 108
APPENDICES --- 121
APPENDIX A: CHEMISTRY SCIENTIFIC CREATIVITY TEST (CSCT) ----------- 121
APPENDIX B: STUDENTS CHEMISTRY SELF- CONCEPT QUESTIONNARE (SCSCQ) -- 127
APPENDIX C: CHEMISTRY ACHIEVEMENT TEST (CAT)---------------------------- 130
APPENDIX D: RESEARCH PERMIT --- 138
APPENDIX E: RESEARCH PERMIT --- 139

LIST OF TABLES

Table 1 Difficulty Index and Discrimination Index of Chemistry Achievement Test 41
Table 2 Summary of the Methods Used in Data Analysis..47
Table 3 Expected Correct Responses 49
Table 4 Correct Responses from the Learners..50
Table 5 Students Performance by Gender 50
Table 6 Expected Correct Responses 51
Table 7 Correct Sample Responses from the Learners..51
Table 8 Students Performance by Gender 52
Table 9 Expected Correct Responses...53
Table 10 Correct Sample Responses from the Learners..53
Table 11 Students Performance by Gender 54
Table 12 Expected Correct Responses...55
Table 13 Correct Sample Responses from the Learners..55
Table 14 Students Performance by Gender 56
Table 15 Expected Correct Responses...57
Table 16 Correct Sample Responses from the Learners..57
Table 17 Students Performance by Gender 58
Table 18 Expected Correct Responses...59
Table 19 Correct Sample Responses from the Learners..59
Table 20 Students Performance by Gender 59
Table 21 Expected Correct Responses...60
Table 22 Correct Sample Responses from the Learners..61
Table 23 Students Performance by Gender 62
Table 24 Expected Correct Response 63
Table 25 Correct Responses from the Learners..63
Table 26 Students Performance by Gender 64
Table 27 Expected Correct Responses...65
Table 28 Correct Responses from the Learners..65
Table 29 Students Performance by Gender 65
Table 30 Expected Correct Responses...66
Table 31 Correct Responses from the Learners..66
Table 32 Students Performance by Gender 67

Table 33 Expected Correct Responses....68
Table 34 Correct Responses from the Learners....68
Table 35 Students Performance by Gender....69
Table 36 Expected Correct Responses....69
Table 37 Correct Responses from the Learners....70
Table 38 Students Performance by Gender....70
Table 39 Expected Correct Responses....71
Table 40 Correct Sample Responses from the Learners....71
Table 41 Students Performance by Gender....71
Table 42 Expected Responses....72
Table 43 Correct Responses from the Learners....73
Table 44 Students Performance by Gender....73
Table 45 Expected Responses....74
Table 46 Correct Sample Responses from the Learners....75
Table 47 Students Performance by Gender....76
Table 48 Expected Correct Responses....77
Table 49 Correct Sample Responses from the Learners....78
Table 50 Students Performance by Gender....79
Table 51 Expected Correct Responses from the Learners....80
Table 52 Correct Sample Responses....81
Table 53 Students Performance by Gender....82
Table 54 Means and Standard deviation by Gender on All Aspects of Scientific Creativity and Overall Scientific Creativity Test....83
Table 55 Independent Sample t-test Results of the difference between Girls and Boys for various Aspects of Chemistry Scientific Creativity....85
Table 56 Person Product Correlation Coefficients for Learners' Scores on the Chemistry Scientific Creativity Test, Chemistry Achievement Test and Learners' scores in planning, sensitivity, flexibility and recognition of relationships Aspects of Creativity....86
Table 57 Number and Percentage of Students and Categories of Creativity....88
Table 58 Learners Categorized Scores by Level of Scientific Creativity and Gender....89
Table 59 Learners Percentage of Categorized Scores by Level of Scientific Creativity and Gender....90
Table 60 Number of Learners by Gender on Each Aspects of Scientific Creativity in Chemistry....91

Table 61 Means and Standard Deviations of the Scores Obtained by Boys and Girls in the Chemistry Scientific Creativity Test (CSCT) 91
Table 62 Test of Significance (t-test, 2-Tailed) for the Difference in Performance between Boys and Girls in Chemistry Scientific Creativity Test (CSCT). 92
Table 63 Person Product Correlation Coefficients for Learners' Scores on the Chemistry Scientific Creativity Test and Chemistry Achievement Test 94
Table 64 Person Product Correlation Coefficients for Learners' Scores in the Chemistry Scientific Creativity Test and Students Chemistry Self-Concept Questionnaire 95
Table 65 Multicollinearity Test on the Independent Variables 97
Table 66 Model Summary of the Multiple Regressions 98
Table 68 The B, t-values and p-values of the Regression Output 99
Table 69 Intercorrelations between Creativity Scores and Students Self-Concept, Culture and Academic Achievement Scores and Gender 10001

LIST OF FIGURES

Figure 1: Multidimensionality and Hierarchy of various Self-concept Constructs. Byrne & Shavelson (1987)....15

Figure 2: Scientific structure creativity model (Hu and Adey, 2002)....27

Figure 3: The mapping of psychological definitions of creativity onto scientific meaning (Okere, 1986)....31

Figure 4 Conceptual Framework of the Study....33

Figure 5 Hierarchical Order on Performance on Aspects of Chemistry Scientific Creativity.84

LIST OF ABBREVIATIONS & ACRONYMS

ARIZ	Algorithm of Inventive Problem-Solving
APU	Assessment of Performance Unit
CAT	Chemistry Achievement Test
CSCT	Chemistry Scientific Creativity Test
CSCQ	Chemistry Self-Concept Questionnaire
IQ	Intelligent Quotient
KICD	Kenya Institute of Curriculum Development
KNEC	Kenya National Examination Council Questionnaire
MoEST	Ministry of Education Science and Technology
SSCM	Scientific Structure Creativity Model
SDQIII	Self-Description Questionnaire III
SCEQ	Students Culture Evaluation Questionnaire
TRIZ	Theory of Inventive Problem-Solving

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

The six internationally agreed education goals aim to meet the learning needs of all children, youth and adults by 2015. The sixth goal aims at improving all aspects of the quality of education and ensuring excellence of all so that recognized and measurable learning outcomes are achieved by all, especially in literacy, numeracy and essential life skills (UNESCO, 2002).

One of Kenya's national goals of education is to promote the social, economic, technological and industrial skills for national development (Kenya National Examination Council, (KNEC), 2002). For this to happen, education in Kenya should produce citizens with skills, knowledge expertise and personal qualities that are required to support a growing economy for industrial development. Secondary school education should therefore provide learners with opportunities to acquire necessary knowledge, skills and attitudes for the development of the self and the nation. It should also develop ability for enquiry, critical thinking and rational judgment as well as the capacity for creativity at all levels of our education system.

Chemistry is one of the three science subjects offered in Kenyan secondary school. The others are Biology and Physics. Chemistry as a subject is introduced to the learners for the first time at secondary school level and creativity is developed through experiments and investigations (KNEC, 2000). Chemistry syllabus emphasizes that learners should; select and handle appropriate apparatus for use in experimental work, make accurate measurements, observations and draw logical conclusions from experiments, use the knowledge and skills acquired to solve problems in everyday life (KNEC, 2000). These are aspects of scientific creativity. The other major objective of Chemistry according to the syllabus is that a learner should be able to apply principles and skills acquired in technological and industrial development. With this in mind the role of Chemistry in the development of the scientific base of a country cannot be over emphasised.

The concept of creativity has been used frequently in various fields of study with different meanings. According to Treffinger, Young, Selby and Shepardson (2000) creativity is the ability to generate ideas, digging deeper into ideas, openness, and courage to explore ideas and listening to one's inner voice. It is an open exploration or search for ideas in which one generates many ideas (fluency in thinking) varied ideas and new perspective (flexibility) and unusual or novel ideas (originality). Creative individuals are divergent thinkers (Guilford, 1959). Guilford drew a distinction between convergent and divergent production (commonly renamed convergent and divergent thinking) (Guilford 1959). Convergent thinking involves aiming for a single, correct solution to a problem, whereas divergent thinking involves creative generation of multiple answers to a set problem. Divergent thinking is sometimes used as a synonym for creativity in psychology literature. Divergent thinking refers to the ability to generate ideas (Treffinger, 2002).

Other researchers have occasionally used the terms flexible thinking or fluid intelligence, which are roughly similar to (but not synonymous with) creativity. The measurable characteristics associated with general creativity are fluency, flexibility, originality, elaboration and metaphoric thinking (Guilford, 1959; Torrence, 1974).

A growing number of psychologists are supporting the idea that there are methods of increasing the creativity of an individual. Several scholars have proposed approaches to prop up this idea, ranging from psychological-cognitive such as; Osborn-Parnes proposed the Creative Problem Solving Process Synectics; Inventium and science-based creative thinking while De Bono (1969) proposed Purdue Creative Thinking Program and lateral thinking. The other highly-structured approaches; TRIZ (the Theory of Inventive Problem-Solving); ARIZ (the Algorithm of Inventive Problem-Solving), both developed by the Russian scientist Genrich Altshuller; and Computer-Aided Morphological analysis.

According to Treffinger (2001) and Loehle (1990) many characteristics associated with creativity are not innate but can in fact be taught and nurtured. They further point out that creative behaviour is influenced by motivational as well as situational factors. In support, Burt (1962) argues that education cannot create creativity but can encourage it and develop it. In support Polya (1957) states that skilful teaching can enhance the ability to discover and the ability to invent. It was therefore of interest to study creativity in chemistry education in Kenyan secondary schools and establish whether it is influenced by learners self-concept, culture, academic achievement and gender.

Scientific creativity depends not only on a well-oiled imagination coupled with habits of hard work but, more importantly, on the ability to integrate in functional ways a wider range of ideas, concepts and skills than is usual. Freeman (1971) stated that creative development can be enhanced through the use of discovery methods. Sommers (1961) found out that in Industrial arts, training that uses discovery method may lead to superior performance in subject matter as well as gain in creative productivity. Torrance (1961) argues that perhaps the most promising areas if we are interested in what can be done to encourage creative talent to unfold, is that of experimentation with teaching procedures which will stimulate students to think independently, to test their ideas and to communicate them to others. Therefore the role of a teacher is to guide and facilitate learning rather than to tell.

According to Piaget (1970) “telling is not teaching”. Moreover a teacher must be able to establish an environment that is learner centred that facilitates collaborative as well as independent learning that encourages taking risks, that fosters problem solving and critical thinking (National Research Council, 1996). According to Okere, Changeiywo and Illa (2010) concept mapping teaching strategy was found to inculcate scientific creativity in students. The findings of the study by Okere et al. (2010) was that concept mapping teaching strategy enhances student’s abilities of recognition of relationships and planning for scientific investigations. Recognition of relationships and planning for scientific investigations are some of the aspects of creativity in science (Okere, 1986). Scientific and general creativity are influenced by many factors such as intelligent quotient (IQ), social-economic status among many others. This study investigated influence of learners’ self-concept, academic achievement, culture and gender on scientific creativity of Kenyan secondary school students.

Self-concept has been defined by different people in different perspectives. According to Lewis (1990) self-concept is an accumulation of knowledge about self, such as beliefs regarding personality traits, physical characteristics, values, goals, roles and abilities. Self-concept can be defined as an idea of self, constructed from the beliefs one holds about oneself and the responses of others. Markus and Nurius (1986) self-concept also called self-identity refers to the global understanding a sentient being has of him or herself. Rathus and Navid (2003) describe self-concept as your impression or concept of you. It includes your own listing of personal traits that you deem important, and your evaluation of how you rate according to these traits. It has much to do with whether you like your-self and by how much.

Research studies have shown that academic achievement and self- concepts were interrelated which has an input on academic effort (Muijs, 1997; Gottlieb and Rogers, 2002; Mboya, 1988; Marsh et al, 1999; Sanchez & Roda, 2005; Popoola, 2002). Academic self-concept and academic achievement have also been found to be strong predictors of each other (Muijs, 1997, Hope et al. 1995; Gottereb & Rogers, 2002 and Sanchez & Roda, 2005).

According to Frederickson (2001) children's levels of self-concept are evident in their behaviour and attitudes. If children feel good about themselves, these good feelings will be reflected in how they relate to friends, teachers, siblings, parents, and others. Self-concept is something that affects individuals throughout life; therefore, it is very important for parents to help their children develop healthy levels of self-concept (Frederickson 2001). There are many things parents can do to help their children learn that they are lovable, capable, and competent, beginning when their children are at a very young age. Unfortunately, it is also at a very young age that children can begin to develop low self-concept. Parents must be very careful not to plant the seeds of low self-concept in their children unknowingly. Self-concept affects school success. Children who feel good about themselves and their abilities are much more likely to do well in school than children who often think they cannot do things right. School success, in turn, affects a child's self-concept. How children do in school will affect how they feel about themselves. Children who do poorly in school often think poorly of themselves (Frederickson 2001).

Some theories suggest that creativity may be particularly susceptible to affective influence. Creativity and positive affect relations according to Isen, Daubman, and Nowiki (1987) has three primary effects on cognitive activity. First; positive affect makes additional cognitive material available for processing, increasing the number of cognitive elements available for association. Secondly positive affect leads to defocused attention and a more complex cognitive context, increasing the breadth of those elements that are treated as relevant to the problem. Positive affect increases cognitive flexibility, increasing the probability that diverse cognitive elements will in fact become associated. Together, these processes lead positive affect to have a positive influence on creativity.

Fredrickson (2001) in her Broaden and Build Model suggests that positive emotions such as joy and love broaden a person's available repertoire of cognition and actions, thus enhancing creativity. According to above researchers, positive emotions increase the number of cognitive elements available for association (attention scope) and the number of elements that are relevant to the problem (cognitive scope).

Self-concept affects creativity. Guilford (1983) argues for the existence of such a relationship between self-concept and creativity, without determining which of these variables comes before the other. This means that having a positive self-concept contributes to the emergence of the human being's creative potential. Furthermore, to the extent that the subject goes through experiences with the environment and gains creative achievements, their positive self-concept will be strengthened. Creativity and self-concept go hand-in-hand. Children with low self-concept are less likely to take the risks involved in being creative than children with a healthy self-concept. Increasing self-concept can help bring a more substantial flow of creative stimulation to one's life. The influence of self-concept on scientific creativity in chemistry has not been studied in Kenya; hence this research was geared toward studying the influence of learner's self-concept on creativity in chemistry education of Form Three students.

Scholars seem not to agree on relationship between creativity and academic achievement. Some researchers such as, Ai (1999); Asha (1980); Getzels and Jackson (1962); Karimi (2000); Marjoribanks (1976); Murphy (1973); Yamamoto (1964), Okere (1986); Ndeke (2003) and Hungi (2009) found that there is a relationship between creativity and academic achievement. Other researchers (Behroozi, 1997; Edwards and Tyler, 1965; Mayhon, 1966; Nori, 2002; Tanpraphat, 1976) showed that creativity was not related to academic achievement in any significant way. This research is prompted by the lack of a final conclusion in the previous research studies conducted on creativity, and how it is related to academic achievement. This study determined the influence academic achievement on scientific creativity in Form Three chemistry students.

According to Ai (1999) past research has usually concentrated simply on whether there is a relationship between creativity and academic achievement without taking into consideration whether the relationship could be dissimilar for the two groups, male and female. Inconsistent findings have been reported on gender differences and creativity. With younger students prior to grade three, Kogan (1974) and Tegano and Moran (1989) found a tendency for girls to score higher than boys. However, boys scored higher on originality in grade three. Coone (1969) and Warren and Luria (1972) found higher scores for girls in early adolescence on figural creativity. Likewise, Torrance (1983) found that gender differences in divergent thinking ability have changed over time. In the 1950's and 1960's boys outperformed girls on measures of originality, whereas girls surpassed boys on elaboration and most measures of verbal creativity (Torrance, 1962/1965). A more recent study in Kenya by Ndeke (2003) found that there was a positive and significant relationship between creativity and gender in Biology. The indications were that creativity skills of sensitivity, flexibility and recognition of relationship were gender dependent in favour of boys but planning was not.

It can be noted from the above studies, that many examinations of gender differences in creativity have shown that girls score higher. While other factors such as birth order, socioeconomic status, teaching strategies, grade level, achievement, and IQ have been explored in regards to creativity, few studies have examined gender differences in creativity among Kenya secondary school chemistry students. This study investigated the influence of gender on scientific creativity in chemistry education of Form Three students.

In the year 2008 the Kenya Government unveiled Kenya’s development blue print (Vision 2030) which proposes intensified application of science, technology and innovation to raise productivity and efficiency levels across the vision pillars; Economic, Political and Social. This is the new country’s development blue print covering the period 2008 – 2030. It aims at making Kenya a newly Industrializing “middle” – income country providing high quality life to all citizen by year 2030 (Republic of Kenya, 2007). Industrial development can only take place if future manpower is trained to think creatively and when they develop capacity for critical thinking in solving problems in any situation and contribute to the technological and industrial development of the nation. To innovate (create) is to successfully invent creative ideas. Innovation is embodiment of thoughts process whereby ideas are transformed into new or improved products, services, processes or organizations. Innovation leading to increased productivity is fundamental source of increasing wealth in an economy. Creativity is important in science education because science is changing rapidly with many discoveries and innovations being made.

According to Treffinger (2001) creativity has much importance. Creative learning helps students to deal effectively, independently and resourcefully with many complete opportunities and challenges. Creativity helps students to deal effectively with future problems and challenges that neither they nor we can even anticipate at the present time. Creativity can have a very powerful and positive impact on student preparation for future careers. Creativity offers rich and varied opportunities for personals growth, expression and productivity. Creativity leads to great satisfaction and reward.

Recently the Kenya Government through the Kenya Institute of Curriculum Development (KICD) came up with the plan of enhancing critical thinking among students as this has been lacking since the implementation of the 8.4.4 education system (Republic of Kenya, 2009). KICD had carried a summative evaluation of 8.4.4. Education system and one of the decisions was to look for ways and means of imparting creative thinking in learners (Republic of Kenya, 2010).This is because accelerated industrial development can only take place if the future manpower is trained to think creatively.

With this in mind, this study investigated the creativity in chemistry education amongst Form Three secondary school students. The study also investigated influence of student's self-concept, academic performance, and gender on scientific creativity in chemistry education amongst Form Three secondary school students in Muranga, Kajiado, Nairobi and Kiambu Counties in Kenya.

1.2 Statement of the Problem

Kenya has developed a new long-term development blueprint for the country titled Kenya Vision 2030. The aim of this vision is to create a globally competitive and prosperous country with a high quality of life by the year 2030. It aims to transform Kenya into a newly-industrialised, middle-income country providing a high quality of life to all its citizens in a clean and secure environment. For this to be achieved Kenya needs highly creative individuals who can be trained through education especially in sciences. One of the general objectives for secondary school chemistry syllabus is to enable learners to develop capacity for creative thinking in solving problems in any situation. The learners should be able to design and carry out scientific experiments and projects that will enable them to understand scientific concepts (KNEC, 2002).

The learners should also acquire the knowledge and skills required to solve problems in everyday life and in technological and industrial development as well as to enable Kenya achieve Vision 2030. All these are aspects of scientific creativity that should be taught in secondary schools. This study established the levels of creativity in chemistry education. Several factors such as student's chemistry self-concept, culture, academic achievement and gender, IQ, family background as well as school environment may be influencing the level of scientific creativity in chemistry learning. However little has been done to establish the influence of such factors on scientific creativity in chemistry learning in Kenyan secondary schools. This study investigated the influence of student's chemistry self-concept, academic achievement and gender on scientific creativity in chemistry education amongst Form Three students in Muranga, Kajiado, Nairobi and Kiambu Counties in Kenya.

1.3 The Purpose of the Study

This study aimed at establishing the influence of student's chemistry self-concept, academic achievement and gender on scientific creativity in chemistry learning amongst Form Three secondary school students. In addition, level of scientific creativity in chemistry education amongst Form Three students was also investigated.

1.4 Objectives

The objectives of the study were to:

i. Determine the level of scientific creativity in chemistry education amongst Form Three chemistry students.

ii. Determine whether there is a difference between Boys' and Girls' scientific creativity in chemistry education.

iii. Determine whether there is a relationship between learners' academic achievement in chemistry education and scientific creativity in chemistry amongst Form Three chemistry students.

iv. Determine the influence of students' chemistry self-concept on their scientific creativity in chemistry education amongst Form Three chemistry students.

v. Explore intercorrelations among scientific creativity in chemistry education, academic achievement in chemistry, learners' self-concept and gender.

1.5 Hypotheses

The following null hypotheses were tested.

H_o1: There is no statistically significant difference between Form Three boys' and girls' scientific creativity level in chemistry learning.

H_o2: There is no statistically significant relationship between academic achievement in chemistry education and scientific creativity level in chemistry education amongst Form Three chemistry students.

H_o3: There is no statistically significant relationship between chemistry self-concept and scientific creativity in chemistry education amongst Form Three chemistry students.

H_o4: There are no statistically significant intercorrelations among scientific creativity in chemistry education, learners' self-concept and academic achievement in chemistry.

1.6 Significance of the Study

Creativity is very important for career preparation among learners hence it is important to inculcate creative skills among learners to prepare them for future careers, if Kenya is to attain vision 2030, it will need creative personnel, who can make, discover and deal effectively, independently and resourcefully with many complex opportunities and challenges facing the country. The findings of the study will inform curriculum developers and implementers that the level of scientific creativity in chemistry is low. This means that the curriculum objective of enhancing scientific creativity in secondary school is not being achieved. The study further found out that academic achievement and chemistry self-concept influence scientific creativity in chemistry by 53.4% therefore if scientific creativity is to be enhanced then the curriculum implementers need to emphasis in academic achievement and chemistry self -concept. The curriculum developers and implementers need also to determine the other factors that influence scientific creativity in chemistry by 46.6%.

1.7 Scope of the Study

The study was carried out in National Secondary Schools in Nairobi and Kiambu Counties and Sub-county schools in Muranga and Kajiado Counties. The study examined influence of only three factors (learner's self-concept, academic achievement and gender) on scientific creativity in chemistry education amongst Form Three students. Form Three students were used because many school principals do not allow the involvement of form four students since they are the examination class hence require no disturbance. The four aspects of scientific creativity are flexibility, recognition of relationship, sensitivity and planning.

1.8 Limitation of the Study

One of the major limitations was the negative attitude towards research held by both the teachers and students. The majority of teachers and students had the feeling of being used by the researchers for their own personal gain while themselves they were not to benefit in any way. This affected teacher's commitment towards the administration of the instruments to the learners and supervision. This could have compromised the responses given in the questionnaire and the answers given in the test. However the researcher took time to explain the importance of this research to the education system in Kenya and to the industrial development of the country to a middle level income economy by the year 2030. This changed the attitude and both the students and the teachers participated willingly in the study.

The other limitation was language barrier especially for students in schools in the interior of Kajiado and Muranga counties. Students in most rural schools use their mother tongue to communicate amongst themselves hence have a challenge with English language. This would have affected their understanding of the test and questionnaire questions which would in turn have affected the findings of this study. This was mitigated by the researcher being present when the students sat the tests and filled in the questionnaire so as to clarify any difficulty cited by the students.

1.9 Assumptions of the Study

This study was carried out with the following assumptions;

i. All Form Three chemistry students had covered Form 1, 2 and 3 chemistry syllabuses effectively.

ii. The sampled students willingly participated in the study and took assignment with the seriousness it deserves.

1.10 Operational Definitions of Terms

The following are definitions of terms as used in this study.

Academic Achievement: Ability to perform tasks in the area of recall, comprehension, application and higher order skills as a result of instruction (Wachanga, 2002). In this study, academic achievement referred to marks scored by learners in the chemistry achievement test.

Chemistry Achievement Test: A set of questions borrowed from KNEC KCSE examination used to measure the student's understanding and mastery of basic principles and concepts in chemistry.

Chemistry Education or Chemistry Learning: Process of learning of chemistry.

Chemistry Self-Concept: Beliefs, hypothesis and assumptions that the individual has about chemistry.

Form Three: The third level in secondary school in Kenyan education system.

Gender: Socially determined personal and psychologically characteristics associated with being male or female namely 'masculinity' and 'femininity' (Garret, 1992), but according to this study gender is the students learned behaviours associated with ones' sex.

Influence: Impact of the independent variables (gender, chemistry self-concept and academic achievement) on the dependent variable (scientific creativity in chemistry).

Level of Scientific Creativity: Described as low or high depending on the criteria reference of 40% of the total scores obtained by the students on the scientific creativity test. The dimensions of scientific creativity measured in this study were;

National Secondary School: A secondary school that uses the Ministry of Education policy to selectively admit top students (411-500 marks for Girls and 420-500 marks for Boys) on KCPE examination merit from all over the country based on quota system

Scientific Creativity: Scientific creativity as a kind of intellectual trait or ability producing or potentially producing a certain product that is original and has social or personal value, designed with a certain purpose in mind, using given information. Hu and Adey (2002). In this study scientific creativity definition by Okere was adopted (Okere, 1986).Possession of the following skills signifies scientific creativity.

Flexibility; ability of the student to give a variety of ideas or solution to a problem

Planning for investigation; ability of the student to devise an experiment to test hypothesis

Recognition of relationships; ability of the student to generate hypotheses regarding the causes of given phenomena or observation

Sensitivity; ability of student to be able to identify sources of errors in designs of scientific investigation and possible solutions to the problem.

School Environment: General school atmosphere that promote or demote perceptions of the human relationships in a school and the school resources available for use in teaching and learning of chemistry concepts.

School Tradition: Rule structures and values practised in a school.

School Category: Classification of school depending on whether it is single sexed (Girls and Boys school), or mixed school (girls and boys together).

Sub-County Secondary Schools: A secondary school that uses the Ministry of Education policy to selectively admit average performer students (290 marks and below for girls, 350 marks and below for Boys). Admission is 100% of its students from the district it is situated.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter reviews literature related to creativity and examines the general, psychological and scientific meaning of creativity. It also reviews literature related to other variables included in the study, self-concept, academic achievement, culture and gender. The chapter finally presents the theoretical and conceptual framework that guided the study.

2.2 Definitions of Creativity

The concept of creativity has been used frequently in many fields with different meanings. According to Britannica Concise Encyclopaedia, (2002) creativity is the ability to produce something new through imaginative skill, whether a new solution to a problem, a new method or device, or a new artistic objects or form. The term generally refers to a richness of ideas and originality of thinking. According to Encyclopaedia of Children's Health, (2011) creativity is the ability to think up and design new inventions, produce works of art, solve problems in new ways, or develop an idea based on an original, novel, or unconventional approach.

Creativity is the ability to see something in a new way, to see and solve problems no one else may know exists, and to engage in mental and physical experiences that are new, unique, or different (Encyclopaedia of Creativity, 2011).

Torrance's definition is often cited for example, sensitivity to problems, deficiencies and gaps in information; making guesses, formulating hypotheses; evaluating and testing; and communicating results (McCracken, 1998). Creativity is a complex of traits, skills, and capacities, including the ability to work autonomously, curiosity, unconventional thinking, openness to experience, and tolerance of ambiguity (Adams-Price, 1998; Albert, 1996). In a summary of scientific research into creativity Mumford (2003) suggested that creativity involves the production of novel, useful products. Authors have diverged dramatically in their precise definitions, with Meusburger (2009) claiming that over a hundred different versions can be found in the literature.

According to Triffinger et al. (2001b) creativity is the ability to generate ideas, digging into ideas, openness and courage to explore ideas and to listening to one's inner voice. In this study creativity is defined as ability to generate many correct responses (flexibility), recognise relationships of chemistry concepts and outside class and class experiences, ability to plan an experiment as well as sensitivity to a problem. According to me creativity is ability to generate new ideas that my result in generation of a new unique products or result in solving a problem.

2.3 Self-Concept

The study of self-concept is vital in the fields of psychology, education and for society in general. Self-concept is widely valued as a desirable educational goal and is frequently posited as a mediating variable that facilitates the attainment of other desired outcomes like academic achievement and creativity among others. A survey of the literature available shows that there is no universal definition of the term self-concept. The lack of consensus in the definition of the term and measuring instrument or research design can be attributed to the many theories of self-concept in existence.

According to Wylie (1961), self-concept can be thought of as an organised confirmation of perception of the self which is admissible to awareness of consciousness. It is composed of such elements as the perception of one's characteristics, attitudes, preferences, ideas, feelings, abilities, precepts and concepts of the self in relation to others or to the environment.
Coopersmith and Fieldman (1974) stated that self-concept: ...... consists of the beliefs, hypothesis and assumptions that the individual has about himself. It is the person's view of himself as convinced and organised from his inner vantage. The self-concept includes the person's ideas of the kind of person he is, the characteristic she possess and his most important striking characteristics (p. 198).

A more elaborate definition of self-concept was given by Zahran (1967). He defines it as*:* an organised, learned, cognitive and unitary configuration of conscious perception, concept, and evaluation by individual, of his self as he actually is (perceived self), as others are supposed to see him (other self) and what one thinks he/ she ought to be (ideal self) (p. 225) Although there is a considerable disagreement on the precise definition of self-concept, social psychologist seem to share a common view that self- concept cannot be directly observed. It can only be inferred from a person's behaviour or self-reported data. In fact, Jersild (1952) argued that one of the distinguishing characteristics of the self is that it can only be defined by the individual because it is only him/her who has access to the experience of self.

According to Byrne and Shavelson (1987), self-concept is structured hierarchically and has three identifiable levels. At the top of the hierarchy is a fairly stable general (or global) self-concept. At the middle level are specific self-concept and physical self-concept. In this level we find feelings about ourselves in specific areas. At the bottom level are more specific sub-areas of self-concept, example mathematic self-concept, science self-concept and peer self-concept. This is illustrated in Figure 1.

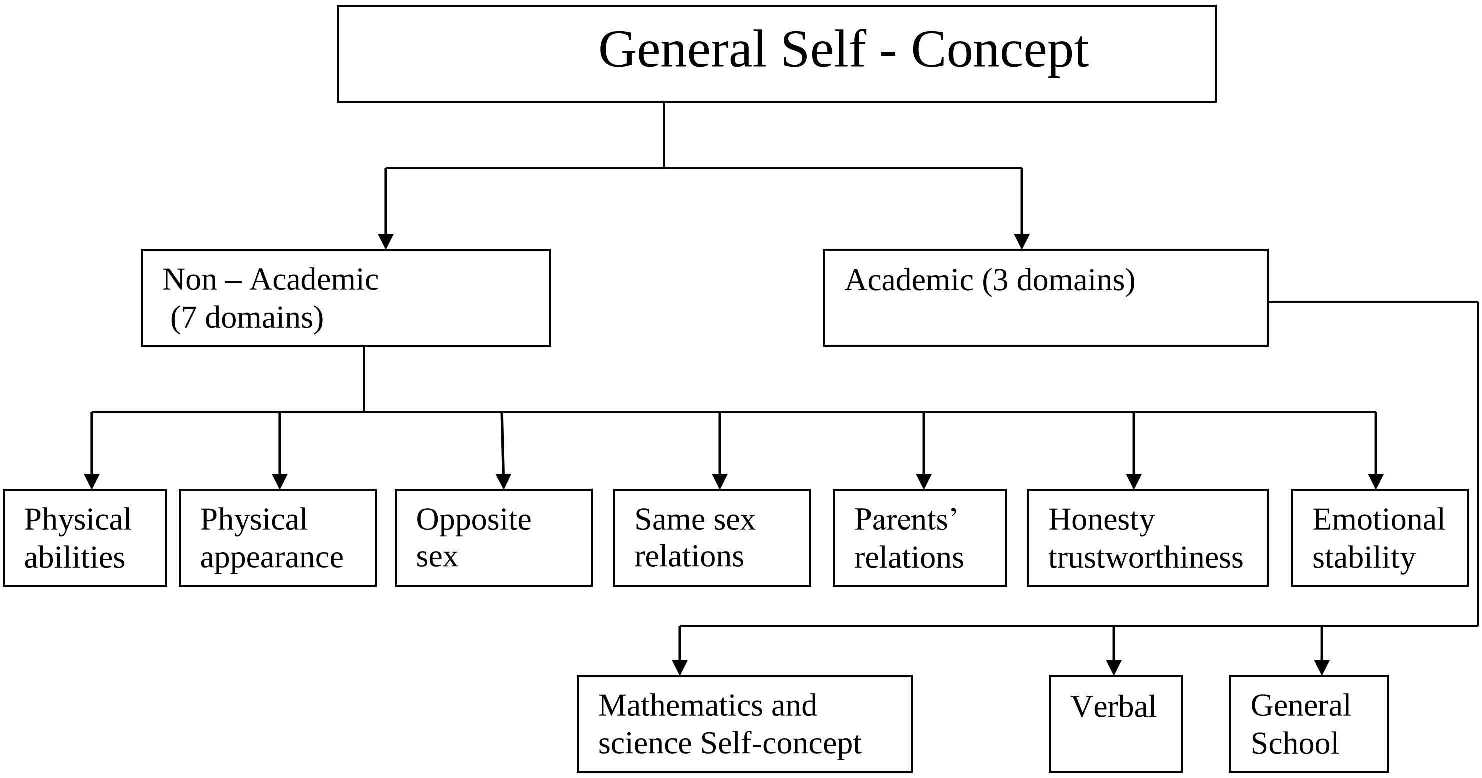


Figure 1: Multidimensionality and Hierarchy of various Self-concept Constructs. Byrne and Shavelson (1987).

Maximising self-concept of ability in an academic subject is recognised as a critical goal in itself and means to facilitate the attainment of the desirable outcomes in education such as academic effort and persistence at task, attributions to failure or success, educational aspirations, academic achievement, course work selection, completion of high school and subsequent university attendance (Marsh, 1991). As seen in Figure 1 one of the elements that affect an individual general self-concept is science self-concept at the bottom of the hierarchy.

It is worth noting that different authors have used both the term self-concept and self-esteem to refer to the same entity. Shavelson and Bolus (1987) and Marsh (1987) are prominent researchers who use self-concept while Rosenburg, Shooler and Schoenbach (1989) use self-esteem. These writers refer to the same thing and even the measures they use are indistinguishable. In this research the term self-concept was used consistently except in cases where quoted research uses the term self- esteem.

2.4 Chemistry Self- Concept

Chemistry self-concept is self-measure of a student's feelings toward chemistry subject or chemistry concepts. The Chemistry Self-Concept Inventory has been developed and contains 40 statements. The statements describe students' feelings towards chemistry as a subject and the concepts taught in chemistry. Participants indicate how accurately each statement describes them on a 7-point scale (1 = very inaccurate, 7 = very accurate).

Bauer (2005) developed this scale to include a science self-construct specific to chemistry. The scale is useful for this evaluation as many science-related attitude and self-concept scales do not concentrate on each science specifically. It is also based on a scale (the SDQIII) that has been subjected to reliability and validity testing and adapted for use in a number of studies (Trautwein, Ludtke, Marsh, Koller, and Baumert (2006).

In this study inventory developed by Marsh and O'Neill (1984) was adopted and modified so as to have self-constructs specific to chemistry eliminating those statements concerned with mathematics learning, academics in general, academic enjoyment, and creativity. The measuring scale was also modified to a 5 point likert-scale of strongly (SA) Agree, Agree (A), undecided (UD), Disagree, (D) and strongly (SD). This was to reduce the choices to the statements hence make it easier for the respondents to make a choice. The terms strongly agree, agree, undecided, disagree and strongly disagree, would be more easily understood by the respondents compared to very accurate, accurate, inaccurate very inaccurate etc. This scale was chosen for a number of reasons. First, there is much debate in the literature about measuring attitudes in science, and most measures have been designed for a specific programme or piece of research. A review of the literature by Blacock et al, (2008), compared measures and concluded the best approach for future research would be to take existing measures, and use them in other contexts to test reliability and to provide further evidence. It was necessary to find a measure suitable for the age group being assessed (Form Three age of 17 years), which narrowed down the number of measures available. Also, it was decided that a focus on finding a measure that assessed students' self-concept and self-efficacy in science, rather than their general attitudes would be most suitable. This study was to establish influence of chemistry self-concept on Kenyan form three secondary school students' scientific creativity in chemistry education.

2.5 Creativity and Self- Concept

According to Burns (1998), self-concept is an organized set of attitudes the individual has towards himself. The attitude has three components:

i. The cognitive component (self-image): refers to the representation or mental perception the subject has of him.
ii. The affective and evaluative component (self-esteem): refers to the evaluation the individual makes of himself.
iii. The behavioural component (motivation): refers to the importance of motivation in behavioural self-regulation processes or conducts.

According to López and Schnitzler (1983), in addition to having the three dimensions mentioned above, the concept of self is characterized as being:

a. An organized system. It serves as a context for integrating new information about oneself, and for integrating and differentiating a vast number of thing learned.
b. Relatively stable. This means that there is a tendency to maintain, over time the concept that one has of oneself, accepting what is consistent with this concept, and rejecting what differs from it.
c. Dynamic. It is a process of continuous change, although directed by a central axis of stability.
d. Multifaceted and hierarchical. It is postulated that there is a general self-concept, plus specific concepts associated with each role the subject plays (Social, physical, academic, etc.) These concepts are organized around the general self-concept, which occupies the top position in the hierarchy.

Thus, self-concept has to do with the image we have of ourselves, and refers to the set of characteristics or attributes we use to define ourselves as individuals and to differentiate ourselves from others. This knowledge is not present at birth, but is the result of an active process of construction, by the subject, throughout the whole time-span of her development.

In general, the authors who mention the issue agree that there is some relationship between these two variables, self-concept and creativity. Concerning this, Guilford (1983) argues for the existence of such a relationship between self-concept and creativity, without determining which of these variables comes before the other. This means that having a positive self-concept contributes to the emergence of the human being's creative potential. Furthermore, to the extent that the subject goes through experiences with the environment and gains creative achievements, their positive self-concept will be strengthened. In connection with the dilemma of which one comes first, authors are divided in their opinions. Some say that a positive self-concept allows the emergence of creative potential, and others say it is the creative capacity that promotes the development of positive self-concept (Moore, Ugarte & Urrutia, 1987).

In the same measure as the person gets to know themselves through the learning achieved via their interaction with the environment, she develops her self-concept. This development facilitates the demonstration of the individual's potentialities, out of which emerges her creative potential (Zegers, 1981). Broc (1994) has studied the effect of a positive self-concept in children's lives. In his studies he has noticed that those children who tend to be more creative; have a lower degree of anxiety; are more open, spontaneous, communicative and curious than children with a negative self-concept. By contrast, the latter perceive themselves as inferior and useless, feel depressed and belittle their potential. In general, these people do not trust themselves and are afraid to express their ideas. As noted above, a positive self-concept can be promoted, although this process takes time and special conditions to achieve it. Thus, a psychological climate of acceptance and respect for individuality, where the subject feels he can have success, and where the people around him accept themselves the way they are, facilitates the development of a positive self-concept in individuals (Espriu, 1993). This study was to find out influence of chemistry self-concept and scientific creativity in chemistry learning or chemistry education.

2.6 Creativity and Academic Achievement

Numerous recent research has been conducted on the subject of creativity in relation to academic achievement (Charlton, 2009; Heinze, Shapira, Rogers & Senker, 2009; Ivcevic, 2009; Miller, 2007; Runco, 2007a, 2007b; Simonton & James, 2007; Yusuf, 2009; Deary, Smith & Fernandes, 2007; Lau & Roeser, 2008; Noftle & Robins, 2007; Steinmayr & Spinath, 2009).

According to one study, creativity is hardly correlated with academic achievement (Ai, 1999). Ai (1999) studied the relation between creativity and academic achievement. In this study, the students were randomly selected from 68 schools (2,264 students, 38% were boys and 62% were girls). Three creativity batteries, the Torrance Test of Creative Thinking (TTCT), the Abedi-Schumacher Creativity Test (CT), and the Villa and Auzmendi Creativity Test (VAT), were administered to the students. Achievement of the students' was assessed using a self-reported achievement in six subject areas: Spanish, Basque, English, natural science, mathematics and social science. A canonical correlation analysis found that when operationalized by their grades, creativity was related to academic achievement for both boys and girls. For girls, elaboration related to four of the academic subject areas (Basque, Spanish, social science and English) and fluency related to natural science and mathematics. For boys, flexibility was the predominant factor that related to all six academic subject areas. When operationalized by the other three measures (TTCT, VAT and CT), on the other hand, creativity was scarcely related to academic achievement. Other researchers also have alluded to the idea that creativity is related to academic achievement (Asha, 1980; Karimi, 2000; Mahmodi, 1998; Okere, 1986; Marjoribanks, 1976; Murphy, 1973).

It is not always the case that studies of the relationship between creativity and academic achievement are consistent with each other in their results (Ai, 1999). Edward (1965) examined 181 ninth grade students and found that for these students; creativity was not related to school achievement. In another research investigation, Nori (2002) studied the gender difference and the type of relationship between creativity and academic achievement among high school students in Shiraz city. There were 306 high school students (150 boys and 156 girls) in the research. To measure the rate of creativity, Nori (2002) used an Abedi questionnaire and CGPA for academic achievement. The results were analysed by CGPA for academic achievement. The analysis revealed that there was no significant relationship between creativity and academic achievement, but the result was different for the two sexes.

Other researchers, such as (Behroozi, 1997; Mayhon, 1966; Tanpraphat, 1976; Torrance, 1962) also supported the view that creativity was not related to academic achievement.

Some investigators have found a low correlation between academic achievement and creativity. Haddon and Lytton (1968) and Krause, (1972/ 1977) found out that creativity had low correlation with academic achievement. Karimi (2000) replicated the studies of Haddon and Lytton 1968 and Krause, (1972, 1977) on secondary school students in the Shiraz school in Iran. The results show the relationship between creativity and academic achievement to be as low as 25%. Ai (1999) wrote that "some researchers in other countries also reported low correlations between school achievement and creativity test scores." Such was the case on Haddon's work done in the United Kingdom. A research on the Federal Republic of Germany and Switzerland (Krause, 1972, 1977) showed that correlations between creativity scores and grades were as low as .09 (physics) or .15 (art). In fact, a longitudinal study from the 7th to the 11th grade in West Germany (Sierwald, 1989) revealed a correlation between creativity test scores and school grades that was actually negative in the case of physics (-.12) and did not go beyond .26, even for art. Similar studies in Kenya by Okere (198; 1988), Ndeke (2003), and Hungi (2009) reported high positive correlations between school achievement and creativity test scores.

The research studies referred to above can classified into three according to their conclusions in respect of how creativity relates to academic achievement. Those that found out that, there is a positive relationship between creativity and academic achievement. (Ai, 1999; Asha, 1980; Getzels, 1962; Karimi, 2000; Mahmodi, 1998; Marjoribanks, 1976; Murphy, 1973; K. Yamamoto, 1964). Other researchers reported that creativity was not related to academic achievement in any significant way (Behroozi, 1997; Edwards, 1965; Mayhon, 1966; Nori, 2002; Tanpraphat, 1976). Yet other researchers deduced that creativity was actually correlated with advanced levels of academic achievement. (Bentley, 1966; Shin, & Jacobs, 1973; Smith, 1971).

What are the possible reasons for the lack of a final conclusion in the previous research studies conducted on creativity, and how it is related to academic achievement? One possible rationalization is that the relationship between creativity and academic achievement is possibly dissimilar for females and males, depending on which special aspects of creativity are being considered. Also, past research has usually concentrated simply on whether there is a relationship between creativity and academic achievement without taking into consideration whether the relationship could be dissimilar for the two groups, male and female (Ai, 1999). With these inconsistent findings this study investigated the influence of academic achievement on scientific creativity level in chemistry education amongst form three secondary school students in Kenya.

2.7 Creativity and Gender

Earlier investigations have revealed that an individual's background characteristics affect his/her cognitive and non-cognitive behaviours (Ai, 1999). Such studies indicated that gender is one of the most significant and influential characteristics in academic achievement (Ai, 1999; Fennema &Carpenter, 1998; Habibollah, Rohani, Tengku Aizan, Jamaluddin & Mallan 2008; Naderi, Abudullah & TengkuAizan 2008).

The importance of examining creativity in relation to gender is based primarily on the socio-cultural differences among girls and boys (Abra, 1991). Traditionally, girls in many societies have been encouraged to conform, whereas boys are expected to be active and dominant risk-takers (Block, 1983). Furthermore, Davis and Rimm (1989) acknowledge that most boys are provided with toys that enhance their visual-spatial abilities, such as trucks, and models, while Lever (1976) notes that the games of girls are often highly structured requiring turn-taking and rules. In addition, characteristic traits of American Indians such as non-assertiveness (Florey & Tafoya, 1988), and the need for modelling (Garrison, 1989) may further impact on existent gender differences in creativity. Social expectations and conformity pressures may create "cultural blocks" to creativity in both girls and American Indians and require further investigation.

Many researchers have studied gender differences in creativity. Flaherty (1992) reported an investigation on the effects of a multimodal program on self-concept and cognitive and affective creativity on students in third grade. Forty-five children from a public elementary school in south western Pennsylvania were divided into two classes. The experimental group consisted of 23 subjects with a male teacher and the control group contained 22 students with a female teacher. The mean age and IQ of the experimental group was 8.7 years and 100 respectively and 9.1 years and 105.9 for the control group. Three paper and pencil instruments were administered: The Torrance Test of Creative Thinking (TTCT), Torrance, (1974), the Piers-Harris Children's Self Concept Scale (Piers-Harris, 1969), and the Creative

Assessment Packet (Williams, 1980). A 12-week intervention was given to the experimental group consisting of sessions which were interactive and involved basics of movement; nature in movement; and pantomimes of different machines, sounds, pictures and math through movement. The results indicated that the girls in the experimental group made significant gains over the boys and the total experimental group scored significantly higher than the control group on the self-concept measure. On the TTCT, the experimental group made significant gains on the elaboration scale of the TTCT, and there were gender differences in overall creativity scores favouring girls. This study involved secondary school students whose age falls between 15-20 years.

Perceptions of creativity among peers have also been investigated. Lau and Li (1996) studied 633 Chinese students in grade five in Hong Kong. Based on peer nominations, the students were placed in five status groups: average, popular, neglected, rejected, and controversial. Through peer nominations and teacher ratings the perception of the students' degree of creativeness was obtained. Among students, boys were viewed to be more creative than girls. Contrasts of the average group with the others were significant except for the rejected group. With teacher ratings, the differences between the average and other groups were less extensive, with only the popular group a little higher than the average group. Peer status and perceived creativity were highly related.

Inconsistent findings have been discovered on gender differences and creativity. With younger students prior to grade three Kogan (1974) and Tegano and Moran (1989) found a tendency for girls to score higher than boys. However, boys scored higher on originality in grade three. Coone (1969) and Warren and Luria (1972) found higher scores for girls in early adolescence on figural creativity. Likewise, Torrance (1983) found that gender differences in divergent thinking ability have changed over time. In the 1950's and 1960's boys outperformed girls on measures of originality, whereas girls surpassed boys on elaboration and most measures of verbal creativity (Torrance, 1962, 1965). Additionally, Bruce (1974) and Torrance, (1963) reported that the gender gap in differences in creativity began to diminish in the 1960's and 1970's. Although divergent thinking is no longer considered to be synonymous with creative ability, it is nevertheless an important component of creative potential (Runco, 1991). A more recent study in Kenya by Ndeke (2003) found that there was a positive and significant relationship between creativity and gender in Biology. The study considered flexibility, recognition of relationships, sensitivity to a problem and planning for experiments. The indications were that creativity in Biology was gender dependent in flexibility, recognition of relationship and sensitivity aspects of creativity. Planning aspect was not gender dependent.

As apparent from the above studies, many examinations of gender differences in creativity have shown that girls score higher. While other factors such as birth order, socioeconomic status, teaching strategies, grade level, achievement, and IQ have been explored in regards to creativity, few studies have examined gender differences in creativity among a single cultural group. Few studies have examined gender differences in scientific creativity level in science education among different culture groups in Kenya. This study investigated the influence of gender on chemistry scientific creativity level in chemistry education among form three students in Kenyan secondary schools.

2.8 Scientific Creativity

The concept of creativity has proven over the years to be an elusive one to define. As early as 1960, Rapucci (cited by Welsch, 1981) counted between 50 and 60 definitions in the literature on creativity. Twenty years later, an extensive review forced Welsch (1981) to conclude that the literature contains such a variance of definitional statements that the task of arriving at an integrated and agreed definition is virtually impossible. Analysis of these definitions suggests that creativity consists of at least four components: (1) the creative process, (2) the creative product, (3) the creative person, and (4) the creative situation (MacKinnon, 1970; Mooney, 1963). According to Hu and Adey (2002), scientific creativity as a kind of intellectual trait or ability producing or potentially producing a certain product that is original and has social or personal value, designed with a certain purpose in mind, using given information.

It is generally accepted that creativity is an important aspect of scientific ability. Problem solving, hypothesis generation, experimental design, and technical innovation all require a particular form of creativity peculiar to science. Alexander (1992) and Amabile (1987) have shown that all creativity has a domain specific component and so there is a need to distinguish scientific creativity from creativity in general. The question of assessing scientific creativity has been considered in detail by Hu and Adey (2002), where a fuller account of the relevant literature can be found. Drawing on previous work on creativity in general (especially the Torrance Test of Creative Thinking – Torrance, 1990) and on domain-specific creativity in particular, they proposed a Scientific Creativity Structure Model. On the basis of this model they designed a paper and pencil test: The Scientific Creativity Test for Secondary School Students, designed for group administration to students aged from about 10 years. There are seven items in the test, each measuring one aspect of scientific creativity: Unusual Uses, Problem Finding, Product Improvement, Scientific Imagination, Problem Solving, Science Experiment, and Product Design.

The scoring rules give credit for fluency, flexibility, and for originality in each item. After Torrance, the test developers took the view that creativity is a composite of these factors, and it is unlikely to be meaningful to try to offer a profile of the separate elements of fluency, flexibility, and originality. By adding scores obtained for each factor, one is allowing for an individual to compensate, say, for lower fluency scores by increased originality scores. In the context of a paper and pencil test which must for practical reasons be given within a specified period this seems to be the fairest way of obtaining a general creativity score for each individual.

2.9 Measurement of Creativity

Various devices for measuring creative thinking are available. For example, Minnesota Multiphase Personality Inventory by Torrance (1974), Make up Problems by Getzel and Jackson (1962), Verbal and Figural creativity tests by Wallach and Kogan (Wallach & Kogan 1965), Test for divergent production by Guilford etc. are mentionable. According to Unesco (1981) some of the tests that are mentioned as Individual/Group Activity include different tests on: - Fluency, Flexibility, Sensitivity, Originality, Redefinition, Elaboration, Word association, Hidden shapes, Alternate uses of things, Completion of fables, Picture construction and so on. These are indicators of general creativity and scientific creativity. This study only included indicator relevant to scientific creativity; Flexibility, Sensitivity, Recognition of relationship and sensitivity to problems.

Operationally, creativity in children is often measured through divergent thinking tests, evaluations of specific productions such as drawings or stories, or parent/teacher nominations (Lubart, 1994; Sternberg & Lubart, 1992). Divergent thinking tests for creativity, such as the Torrance Tests of Creative Thinking or the tests proposed by Wallach and Kogan, require children to produce as many original ideas (uses of an object, questions, consequences, and titles for a picture) as possible concerning a stimulus (Torrance, 1974; Wallach & Kogan, 1965). This stimulus may be a hypothetical situation (e.g., strings attached to clouds), a drawing (e.g., picture of a boy who looks in the water), an object (e.g., a box, a paperclip), or other things. These tests are usually time limited (5 to 10 minutes for a task). Divergent thinking tasks provide three indices of performance: fluency which is the number of ideas produced; flexibility, which is the number of different categories from which the ideas are drawn, and originality of the ideas which is production of new ideas (Mouchiroud and Lubart, 2001). Some divergent thinking tasks take into account the elaboration of ideas, or the number of details included in the productions. An alternative to divergent thinking tests is the use of integrated production tasks in which the child must produce an elaborated idea, such as a short story, a drawing, a collage, or a musical composition. This production is then evaluated by adult judges for its creativity. Finally, creativity may be measured by asking parents or teachers to nominate children who show creative thinking in their actions at school or at home. Of course, each of these three types of creativity measures has its strengths and weaknesses (Lubart, 1994).

The Torrance Test of Creative Thinking is the most commonly used test for general creativity worldwide, but has technical flaws that cause Lubart (1994) to question the accuracy of the results. Lubart (1994) posits that in order for the results of these tests to truly show the level of creativity within individuals from different cultures, and for cross-cultural comparisons to be made, these tests must be adapted to the culture in which they are used. All the above tests are for general creativity and have limitations in assessing scientific creativity (Okere, 1986; Hu and Adey, 2002; Torrence, 1990; Oche, 1990).

However, general creativity tests cannot do when assessing scientific creativity. There is a general consensus that domain-specific knowledge and skills are a major component of creativity. Alexander (1992) and Amabile (1987) emphasized the need for specific domain or discipline-based knowledge and skills for creative thinking. This issue was also addressed by Findlay and Lumsden (1988) and Mumford, Mobley, Uhlman, Reiter-Palmon, and Doares (1991) who defined being knowledgeable as having a knowledge base that is conceptually well-organized and for which retrieval is fluent and efficient in relation to demand in a given problem-solving or creative thinking situation. Other researchers (Gardner, 1983; Feldman, 1974) also concluded that creativity is domain specific. As Barron and Harrington (1981) suggested, more domain-specific aspects of divergent thought may underlie creative productivity. According to his research, Sternberg, (1996) concluded that the correlation coefficient between different creativity areas is only 0.37. Therefore the scientific creativity of secondary school students, a kind of domain-specific creativity, cannot be measured by tests designed for other content areas or age groups.

A more recent three dimensional model of scientific creativity has been developed in Kings College, London (Hu and Adey, 2002). The three-dimensional Scientific Structure Creativity Model (SSCM) consists of three dimensions; Personal traits, Process and Scientific Product.

Personal Trait: This is the first dimension of (SSCM) consisting of;

Fluency which means the number of original ideas produced, flexibility which is the ability to 'change tack', not to be bound by an established approach after that approach is found no longer to work efficiently and originality which is interpreted statistically as an answer which is rare or an answer that occurs only occasionally in a given population, is considered original.

Fluency, flexibility, and originality thus form one dimension of the model, one which can be described as being a personality trait, the characteristics of the creative person.

Product (scientific Products): This is the second dimension of SSCM consisting of; technical products, advances in scientific knowledge, understanding of scientific phenomena, and scientific problem solving (sensitivity to science problem).

The Process: This is the third dimension of SSCM consisting of the process an individual undergoes in the process of being creative. This suggests a distinction between creative imagination and creative thinking.

The three-dimensional Scientific Structure Creativity Model SSCM which arises from this analysis is shown in figure 1. The proposed structure is designed as a theoretical foundation on which the measurement of scientific creativity and the cultivation of scientific creativity may be based.

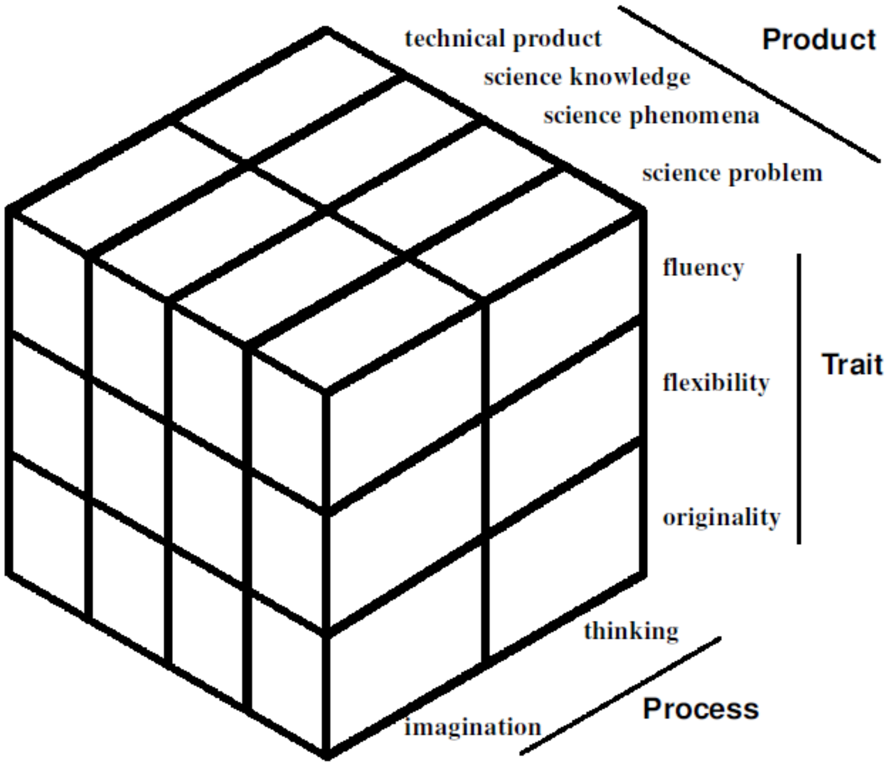


Figure 2: Scientific structure creativity model (Hu & Adey, 2002)

2.10 Meanings of General Creativity

According to Treffinger, et al, 2002, ed. creativity is ability to generate; ideas (fluency in thinking), varied ideas and new perspectives (flexibility) and unusual or novel ideas (originality). All these are aspects of divergent thinking where divergent thinkers move away from responses already known and expected. The other aspects are elaboration and metaphorical thinking (sensitivity to defect and missing elements). All these aspects are measurable.

2.11 Meanings of Creativity that have Relevance to Science Education

Okere (1986) has summarized the psychological meanings or aspects of creativity that have relevance to science education under the following headings: sensitivity to problems, recognition of relationship, flexibility in reasoning and planning for investigations.

2.11.1 Sensitivity to Problems

This is defined as the ability to be aware of problems and think of possible solutions to the problems (Guilford, 1950; Torrance, 1959; Oche, 1990). This ability may be assessed in chemistry by setting problems that require students to identify inadequate scientific arguments, state possible sources of experimental errors, or criticize given experimental procedures. This is what Hu and Adey (2002) categorise as scientific problem solving sub-dimension of the Product (scientific product) dimension of SSCM. Lubart (1994) pointed out that problem solving can lead to creativity because if a problem exists then there is the possibility of creative solution. Hu and Adey (2002) state that sensitivity to science problems is also considered a component dimension of scientific creativity. Ochse (1990) argued that sensitivity to problems is an important feature of the creative process. According to Cattell (1971) problem solving does not mean solving routine problems using a recipe but finding the answers to new problems. Einstein and Infield (1938) suggested that the formulation of a problem is often more important than its solution, which may be a matter of mathematical or experimental skill. Okere (1986) gives scientific meanings of creativity that map sensitivity to the problem as design of investigation. This includes the following activities;

a. Reformulating General Statements

In this case a student should be able to rephrase statements in such a way that they could be checked scientifically. This means that a student should first be able to identify the inadequacy of a given statement and also suggest an experiment that could be used to check the rephrased statement and control variables.

b. Criticizing Experimental Procedure

In this case the student should be able to identify what is wrong with an experimental procedure. The student should be able to identify the variables that need to be controlled to make the results of the investigation fairer, and explain the need to control such variables

c. Describing the Sequences of Investigation

Here the student should be able to describe a given experiment that would be used to investigate a particular problem. In doing this, a student describes the sequences of investigations and explains the criteria to be used in determining the dependent variables.

d. Devising and Describing Investigations

Here a student is not given the outline of an experimental procedure to be followed hence the student is expected to decide what experimental procedure to use.

2.11.2 Recognition of Relationships

Psychologists suggest that a creative individual should be able to recognize relationships among concepts and retrieve earlier experiences whenever he encounters novel situations (Rogers, 1954; Brunner, 1957; Cropley, 1967).This ability can be assessed best by problems that require the application of chemistry concepts to everyday problems.

Brunner (1957, 1963) argues that a creative individual should not see data as unique but as part of related sequence of events which the environment has been providing. Okere (1986) gives recognition of relationships scientific definition as generating hypothesis. For a student to be able to generate hypothesis he needs to have an understanding of scientific phenomena. According to Okere (1986) generating hypothesis involves;

A. Selecting a Correct Hypothesis from Given Alternatives

In this case the student should be able to select a correct hypothesis from given alternatives. This will require a student to first recognise relationships between particular chemistry concepts and the expected outcomes before selecting the correct hypothesis. The student should also give reasons for whatever choice they made.

B. Generating a Hypothesis from a Particular Topic Area

Here the student suggests causes of given physical phenomenon or described observations. This requires the student to generate a hypothesis based on particular topic and give reasons for deciding on the particular hypothesis.

C. Generating a Hypothesis from Many Topic Areas

In this case the student should elicit many possible hypotheses from various science topics when explaining causes of observed phenomenon. In this study the focused on the assessment of the above skills among Form Three chemistry students in National schools.

2.11.3 Flexibility in Reasoning

This is defined as the ability to produce a great variety of ideas even when it is not necessary to do so (Guilford 1950; Barron, 1969; Kuhn, 1959). Hudson (1990) and Torrence (1990) give a case for flexibility, fluency and originality. According to Wilson (1954) there are two types of flexibility; Spontaneous flexibility, which is the ability to produce a great variety of ideas, with freedom from inertia and adaptive flexibility which facilitates the solution of problems.

Okere (1986) states that the ability can be assessed by problems that calls for reasoning so that students have the freedom to give all possible reasons. Alternatively it may be assessed by design problems that give room for various ways of solving a particular problem. The scientific definitions of flexibility are design of investigations where various designs are suggested and generating hypotheses from one or various topics.

2.11.4 Planning for Scientific Investigations

The ability to devise experiments to test hypotheses (Parnes, 1963; Hudson 1967 & Washton, 1966).This skill can be assessed by constructing problems that require the identification of control variables. It can be displayed in problems that require students to propose and devise experiments to test hypothesis. The scientific definition of planning is design for investigation. This involves;

I. Reformulating General Statements

In this case a student should be able to rephrase statements in such a way that they could be checked scientifically. This means that a student should first be able to identify the inadequacy of a given statement and also suggest an experiment that could be used to check the rephrased statement and state the control variables.

II. Criticising Experimental Procedures

In this case the student should be able to identify what is wrong with an experimental procedure. The student should be able to identify the variables that need to be controlled to make the results of the investigation fairer, and explain the need to control such variables.

III. Describing the Sequences of Investigation

Here the student should be able to describe a given experiment that would be used to investigate a particular problem. In doing this, a student describes the sequences of investigations and explains the criteria to be used in determining the dependent variables.

According to Okere (1986, 1996), the above psychological definitions of creativity and their scientific meanings or definitions are displayed in his model shown in Figure 3. This model guided the development of Chemistry Scientific Creativity Test (CSCT) which was used in this study to measure the level of scientific creativity in chemistry education of form three students.

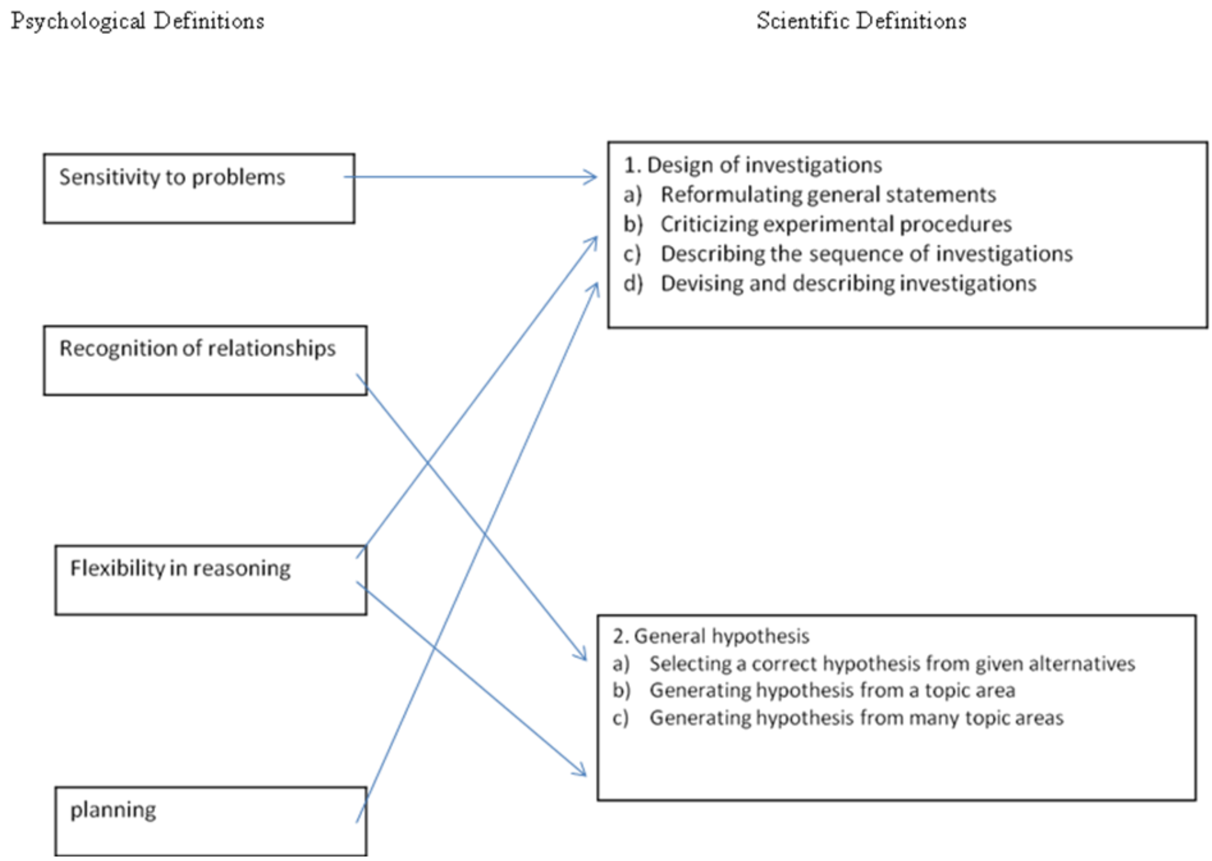


Figure 3: The mapping of psychological definitions of creativity onto scientific meaning (Okere, 1986)

2.12. Theoretical Framework

The theoretical framework of this study was Guilford's model of intellect derived from his work in the field of education the Cognitive Process of Creativity. According to Guilford, (1950) creativity is a function of a cognitive process which means a volitional mental operation that can be learned in much the same way as solving a mathematical equation or speaking another language. Guilford's model describes several types of thinking functions with certain combinations of those functions underling creativity. He feels that creativity is part of the divergent, convergent, and evaluative thinking operations.

1. Divergent Thinking - the ability to move along different paths or directions from given information.
2. Convergent Thinking - is the ability to bring together several pieces of information to a focal point of a single correct answer.

3. Evaluation - the ability to make decisions based upon correctness, suitability, and adequacy.

It is measured by the flexibility, fluency, and originality of responses to a given problem situation. It is also measured by the sensitivity of an individual to a problem and the ability to redefine information. Flexibility is the ability to generate a variety of transformations. These three; flexibility, fluency, and originality are part of the divergent thinking model. Sensitivity to problems is in the evaluative mode. The individual must be able to evaluate situations for unmet needs in order to bring about improvement. The convergent thinking mode is used to redefine information. The product is a transformation. A lot of creative effort is in the form of transforming something known into something not previously known.

From Guilford's model of divergent thinking, a creative individual should be divergent in thinking which can be measured by flexibility, fluency, originality and sensitivity of an individual response to a problem situation. This is for general creativity. This study aimed at investigating the level of some of these creativity aspects amongst Form Three students in chemistry education. Okere's model (1986) (Figure 3) which maps psychological definitions of creativity onto scientific meanings also guided this study. This model gives the scientific meanings as sensitivity to problems, flexibility in reasoning, planning and recognition of relationships. All the 4 scientific meanings were tested in the CSCT instrument formulated to measure scientific creativity level amongst form three students.

2.13 Conceptual Framework

Diagrammatic representation of the interaction of the various variables in the study is illustrated in Figure 4.

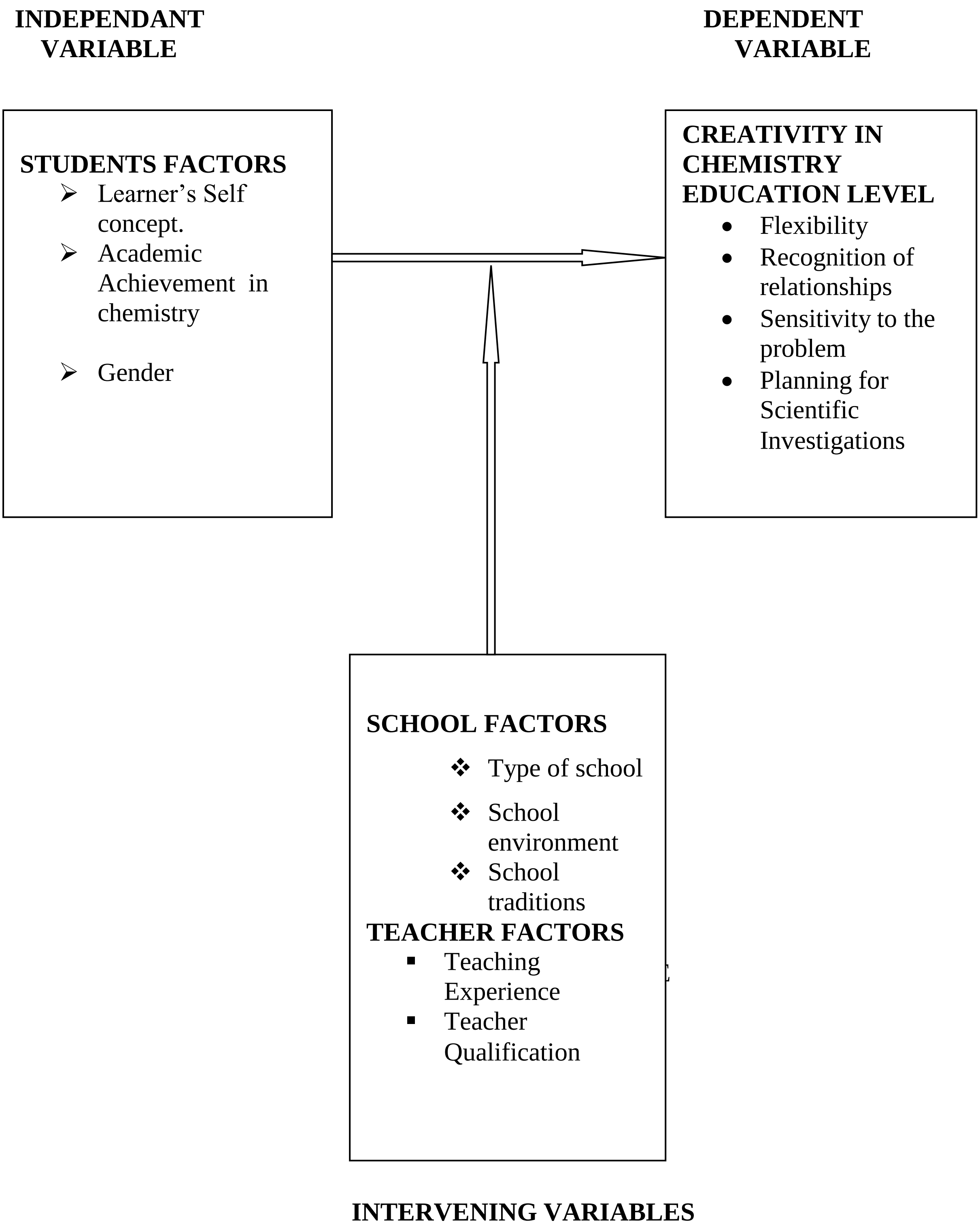


Figure 4 Conceptual Framework of the Study

This study focused on the influence of learner's self-concept, academic achievement in chemistry and gender on scientific creativity in chemistry education. Scientific creativity is influenced by many factors such as age, family socioeconomic status IQ and others. These factors constituted the independent variables but only 3 factors were investigated which were student's self-concept, academic achievement in chemistry and gender. In addition to the above 4 factors scientific creativity is also influenced by intervening variables such as teachers factors; teacher experience and teacher qualification as well as school factors such as; type of school, school environment and school tradition. These intervening variables were not studied but were controlled.

Teacher experience was controlled by involving only public secondary schools since most of the teachers are trained. Teacher qualification was controlled by involving only classes taught by trained (Diploma or Graduate) chemistry teachers. Other intervening variables are schools factors such as; type of school, school environment and school tradition. These intervening variables were controlled through involving two types of schools (National and County). Random selection of schools helped minimise the effect of school factors.

The single directional arrow from independent variable towards dependent variables indicates that student's scientific creativity in chemistry may be influenced by the student's factors (learner's chemistry self-concept and gender) and academic achievement in chemistry. The intervening variables must be there for the independent variable of impact on the dependent variable.

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Introduction

This chapter discusses the research design used in the study, target population, sampling procedures and instruments used in this study. Data collection procedures and data analysis techniques are also discussed.

3.2 Research Design

The study involved ex post facto research in which the researcher used causal- comparative and correlational designs. In causal-comparative research variables cannot be manipulated for ethical and practical reasons because the effect of the variable has already occurred (Lodico, Spaulding & Voegtle, 2006). According to Fraenkel (2006) causal-comparative research is an attempt to identify a causative relationship between an independent variable (in this study gender, academic achievement and chemistry self-concept) and a dependent variable (in this study scientific creativity in chemistry). In other words investigators attempt to determine the cause or consequences of differences that already exist between or among groups of individuals. He further indicates that the relationship between the independent variable and dependent variable is usually a suggested relationship (not proven) because the researchers do not have complete control over the independent variable. The other key characteristic of causal-comparative research is that individuals are not randomly assigned to groups as the study is involving an event or situation that has already occurred with groups that are already formed (Lodico et al., 2006).

On the other hand, correlational research does not allow researchers to determine what variable causes an effect on another variable rather; correlational research allows researchers to determine the relationship or association between two or more variables. Neither correlational nor causal-comparative researches produce experimental data (Gay, Mills, & Airasian, 2006) instead; both research methods are non-experimental methods of data collection (Lodico et al.). In this study the variables were scientific creativity in chemistry (dependent), student chemistry self-concept, gender and academic achievement (independent variables).

3.3 The Target Population and Accessible Population

The target population was all the form three students in all secondary schools in Nairobi, Muranga, Kiambu and Kajiado counties in Kenya. The accessible population was Form Three Students in National schools in Nairobi and Kiambu County and County schools in Muranga and Kajiado counties of Kenya. National schools represent the top cream of academic ability in Kenya. Only those students pass very well in the Kenya Certificate of Primary Education KCPE make it to these prestigious National schools in Kenya. National schools admit high performers from all counties of the republic. These schools admit students with high marks with an average of 400 marks. County schools on the other hand admit average performers and admission is 100% of students from the county where the schools are situated. Both National and County schools were used in this study to take care of school characteristic which were intervening variable.

Form Three students were involved in this study because the school administrators are always reluctant to allow the use of Form Four classes since they are an examination class. The Form Three students were appropriate for the study since they had covered enough chemistry content for the purpose of this study.

3.4 Sample Size

The guidelines given by Gall, Borg and Gall (1996) were followed in determining the sample size. Where correlation coefficient (r) is used to test hypothesis at 0.05 level of significance a minimum sample of 384 cases is required. When the independent sample t test is used, a minimum sample of 386 is required. Fraenkel, 2006 suggests that if participants are to be grouped large sample size is recommended. In view of this, a sample of 672 students was selected for the study.

3.5 Sampling Procedure

3.5.1 Selection of Participating Schools

Lists of all National schools and County schools in the counties under study were obtained from the Nairobi, Muranga, Kiambu and Kajiado County Education Offices. These lists formed a sampling frame of the National schools and County schools. Using stratified random sampling method 8 National (4 boys only and 4 girls only) were selected from Nairobi and Kiambu counties. Similarly using stratified random sampling method 8 County were selected from Muranga and Kajiado counties.

3.5.2 Selection of Participating Stream

Many schools had more than one Form Three class (stream) and only one stream per school was involved in the study. The selection of the stream of study was through simple random sampling procedure.

3.6 Instrumentation

Four instruments were used in this study. These are;

a) Chemistry Achievement Test (CAT)
b) Chemistry Scientific Creativity Test (CSCT)
c) Students self-concept Questionnaire (SSCQ)

These instruments are discussed in the subsequent sub-sections.

3.6.1 Chemistry Achievement Test (CAT)

The CAT was aimed at assessing the students' knowledge of chemistry concepts. The test items were drawn from the same KCSE chemistry syllabus the CSCT was drawn. The CAT had 30 test items. The items were adopted from the Kenya Certificate of Secondary Education (KCSE) national examination papers. All the items were open-ended and were drawn from all the topics taught from form one to form three. It was aimed at assessing learners' academic performance in chemistry. After careful editing by the researcher the CAT was given to a specialist in chemistry education to moderate the items before piloting was done. The CAT was piloted in two schools in Nakuru County. The results from pilot study were used to determine its validity and reliability.

3.6.1.1 Validation of the CAT Items

The test items and scoring key were validated by a team of experts comprising of university chemistry education lecturers and secondary school chemistry teachers. For consistency the same experts who validated the CSCT were used to validate the CAT. The experts' feedback was used to improve the test items thus making them more appropriate for the research. The CAT was then piloted alongside the CSCT using the same schools and students.

3.6.1.2 Reliability of CAT

Items in CAT were not scored dichotomously. Scores ranged from 1- 5 marks. Since the items yield a range of scores the reliability coefficient of the test was estimated using Cronbach's coefficient alpha. (Thorndike & Thorndike, 1994).

To estimate the reliability of such instrument Ebel and Frisbie (1991) and Borg and Gall (1989) recommend the use of Cronbach's coefficient alpha. The reliability coefficient of 0.7 and above for teacher made test is acceptable (Ebel and Friesbie, 1991). A reliability coefficient of 0.80 was obtained. This reliability fall within the acceptable limit for teacher made tests.

3.6.1.3 Item Analysis of CAT

Item analysis is the process of collecting, summarizing and using information from students' responses to assess the quality of test items (Mitra, Nagaraja, Ponnudurai and Judson (2009). To determine the efficiency of the test items used in research two factors are normally employed; discrimination index (D.I) and difficult Index (D.I).

Anastasi (1982), Mulder (1989) and Lokeshkoul (1992) give difficulty index of an item and discriminating index as the criteria for selecting items. Difficulty index expresses the degree of difficulty or easiness of an item while the discriminating index expresses the ability of an item to discriminate between poor and good students. The results obtained from the pilot study were used to compute the difficulty level and discrimination index for each of the items.

a) Difficult Index (D.I) of CAT

D.I of a test item is a measure of its difficulty level. Marshall (1971) says for a test item with scores of more than one point , the facility index is interpreted to mean average number of points obtained by examines on the test item divided by the maximum number of points allocated for it. For objective test items, on which an examinee scores either one or zero, the D.I represents the proportion of examinee who answered the test item correctly. Quality of the test items was assessed to ensure that they are not too difficult and not too easy, as well as whether the test effectively differentiates between students with high, moderate and low level of creativity of form three students in chemistry. To determine the difficulty level of test items, a measure called the Difficulty Index is used. A rough "rule-of-thumb" is that if the item difficulty is more than 0.75, it is an easy item; if the difficulty is below 0.25, it is a difficult item. The formula below was used to calculate the D.I.

$$D..I.\frac{S_H - S_L - 2NXScores_{\min imum}}{2N(Scores_{\max imum} - Scores_{\min imum})}$$

Where;

S_H is the sum of scores for "high"

S_L is the sum of scores of " low"

N is 25% of the number tested

Scores $_{maximum}$ is the highest possible scores on the items

Scores $_{minimum}$ is the highest lowest scores on the items

(Noll, et al. (1979).

b) Discrimination Index (D.I) of CAT

In addition to item difficulty, item discrimination is an important index. This provides information on how effectively the items in a given test discriminate between students who are higher in the ability measured (scientific creativity) and those who are low Mitra et al. (2009). The test is said to have a *positive discrimination index* (between 0 and 1) indicating it can discriminate between students who are higher in the ability measured (scientific creativity) and those who are low. When a test has a *negative discrimination index* (between -1 and 0) it means it cannot discriminate between students who are higher in the ability measured (scientific creativity) and those who are low.

Brown (1983) and Crocker and Algina (1986) have reported that any discrimination index of 0.2 or higher is acceptable and the test item would be able to differentiate between the weak and good students. According to Frazer and Sleet (1975) a good test item should have a discrimination index of 0.30 and above. Questions found to have a negative discrimination indices or below 0.30 or with negative discrimination index were either moderated with the assistance of experts in the faculty of education to remove ambiguities, inaccuracies and other errors as advised by Lokeshkoul (1992). Anastas (1982) argues that the appropriate difficult index and discrimination index of a test depends on the purpose of the test. Mulder (1989) argues that difficult and discrimination indices are not the only criteria for deciding appropriateness of an item. Certain items need not be discarded if they are dealing with an important aspect of the field of investigation. One inadequacy of only analysing a question in terms of its difficulty index is the inability to differentiate between students of widely differing abilities. Subjective judgment of item difficulty by item writer and the vetting committee may allow faulty items to be selected in the item bank. Items with poor discrimination index and too low or too high difficulty index should be reviewed by the respective content experts, Meshkani and Abadie (2005). For calculation of the discrimination index this study used the method adopted by Kelley (1939) where upper and lower 27% performers were selected. The only limitation of this test is that it cannot be used for a smaller sample size. But in this study, the sample size was 640 hence the observed results truly reflected the discriminative power of the test items used.

The formula below was used to calculate the D.I of the test items:

$$D.I = \frac{\sum X_{i(U)}}{(X_{i\max})N_U} - \frac{\sum X_{i(L)}}{(X_{i\max})N_L}$$

Where;

$X_{i(U)}$ = Scores obtained on test item i by the respondents in the upper group (high achievers)

$\Sigma X_{i(U)}$ = Sum of scores obtained on test item i by the respondents in the upper group

$X_{i(L)}$ = Scores obtained on test item i by the respondents in the lower group (low achievers)

$\Sigma X_{i(L)}$ = Sum of scores obtained on test item i by the respondents in the lower group

$X_{i\ (max)}$ = The maximum possible scores for test item i

$N_{(U)}$ = The respondents in the upper group

$N_{(L)}$ = The respondents in the lower group

This formula is simplified to;

$$D.I = \frac{X_{i(U)} - X_{i(L)}}{X_{i(\max\ x)}}$$

Where; $X_{i(U)}$ = The average scores of the upper group (high achievers) on the test item i

$X_{i(L)}$ = The average scores of the upper group (high achievers) on the test item i

$X_{i(\max)}$ = The maximum possible scores for test item i

Table 1
Difficulty Index and Discrimination Index of Chemistry Achievement Test

Item	Difficulty Index/ Facility Index	Discrimination Index	Item	Difficulty Index	Difficulty Index
1a	0.58	0.68	19	0.17	0.1
1b	0.92	0.68	20a	0.35	0.5
1c	0.31	0.54	20b	0.37	0.64
2	0.29	0.35	21	0.16	0.32
3a	0.62	0.62	22a	0.6	0.64
3b	0.42	0.84	22b	0.55	0.82
4	0.28	0.51	22c	0.48	0.76
5	0.47	0.86	23a	0.66	0.92
6	0.18	0.28	23b	0.54	0.92
7	0.5	0.72	23c	0.34	0.62
8	0.62	0.52	24	0.1	0.2
9	0.56	0.64	25a	0.66	0.12
10a	0.42	0.68	25b	0.45	0.66
10b	0.58	0.72	25c	0.79	0.38
11	0.5	0.62	25d	0.44	0.78
12	0.48	0.68	26a	0.24	0.44
13	0.14	0.25	26b	0.03	0.06
14	0.1	0.04	27	0.12	0.24
15	0.0	0.0	28	0.34	0.68
16	0.42	0.78	29	0.21	0.24
17	0.29	0.52	30	0.07	0.86
18	0.06	0.1	31	0.28	0.28

The difficulty level of the chemistry achievement test ranged between 0.0 and 0.92 while the discrimination index ranged between 0.0 and 0.92. According to (Lokeshkoul, 1992; Noll et al.1979) an ideal item should have a difficult index of between 0.40 and 0.60 and a discrimination index of 0.2 and above for most testing purposes. However according to Anastasi (1992) the appropriate difficulty level depends on the purpose the test. She further argues that for a test testing mastery of skills or knowledge even very easy or difficult items yielding a low percentage of passing may be included.

Considering the difficulty index and discrimination index values given in Table 2 some items did not meet the threshold recommended. Items 1a, 6, 13, 14, 15, 18, 19, 20a, b, and c, 24, 26a, b, 27, 28, 29, 30, 31 did not meet the recommended threshold of item difficulty index. On the other hand item 14, 15, 18, 19, 25a and 26b did not meet the ideal discrimination index. However for items 1a, 6, 13, 15, 20a, 20b, 21, 24, 26a, 27, 28, 29, 30, and 31 despite having not met the ideal difficult index they met the threshold discrimination index. Therefore these items were retained. However Items 14, 18, 19, and 26 that did not meet the threshold of difficulty index and discrimination index were thoroughly scrutinized for any ambiguities, inaccuracies and any other errors as advised by Lokeshkoul (1992). Mulder, (1989) argues that difficulty and discrimination indices are not the only criteria for deciding the appropriateness of an item. Certain items can be retained if they deal with an important aspect of the field of investigation. For this reason that they deal with the topics prescribed in the syllabus they were retained.

Mitra et al, (2009) states that when the difficulty index is very low, indicating difficult question, it may be that the test item is not taught well or is difficult for the students to grasp. It also may indicate that the topic tested is inappropriate at that level for the student. In addition the quality of test items may be further improved based on action taken in reviewing the distracters by the item writer based on the calculated discrimination and difficulty index values. They further state that some common causes for the poor discrimination are ambiguous wording, grey areas of opinion, wrong keys and areas of controversy. Items showing poor discrimination should be referred back to the content experts for revision to improve the standard of these test items.

Correlation was tested between individual item's difficulty index and discrimination index score. Pearsons correlation coefficient (r) was found to be 0.599**. The correlation is positive and significant at 0.01 levels (2-tailed). Negative correlation signifies that with increasing difficulty index values, there is decrease in discrimination index. As the items get easy (above 75%), the level of discrimination index decreases consistently. Positive correlation between difficulty and discrimination index indicated that with increase in difficulty index, there is increase in discrimination index. As the test items get easier, the discrimination index decreases, thus it fails to differentiate weak and good students. Si-Mui and Rashia (2006) found that maximum discrimination occurred with difficulty index between 40 – 74%.

3.6.2. Chemistry Scientific Creativity Test (CSCT)

The Chemistry Scientific Creativity Test (CSCT) (Appendix 1) had 13 items some (5) formulated by the researcher and some (2) adapted from the Assessment of Performance Unit (A. P. U.) tests. Other questions (6) were adapted from the KNEC examination papers. The Scientific Creativity Test developed by Hu and Adey (Appendix 5) was not found appropriate for this study because it was for general science concepts while this study is specific to Scientific Creativity in Chemistry Education. All the items in the CSCT were open-ended with each question testing different aspect of creativity. The test was aimed at assessing Form Three students' competence in scientific creativity abilities which include; recognition of relationships, flexibility, sensitivity to the problems and planning of investigation in chemistry.

These maps onto the scientific meaning of creativity, (Fig. 3, page 33). The test was piloted with 160 Form Three students in two schools (two National and two District school) with the same characteristics as the sample schools from Nakuru County. A specialist in scientific creativity and science education moderated the CSCT items and the scoring key before piloting.

Validation of the CSCT Items

Specialists in chemistry education and in creativity in science education of Faculty of Education and Community Studies of Egerton University moderated the CSCT items and the scoring key before piloting. After piloting some of the items that were found to be ambiguous were revised, modified and retained in the final test.

Reliability of CSCT

Items in CSCT were not scored dichotomously hence yielded a range of scores. To estimate the reliability of such instrument Ebel and Frisbie (1991) and Borg and Gall (1989) recommend the use of Cronbach's coefficient alpha. Cronbach's coefficient alpha was used to estimate reliability of the items in the CSCT. According to Fraenkel and Warren (1990), a reliability coefficient of above 0.7 is considered suitable to make possible group inferences that are accurate.

The Cronbach's alpha coefficient was calculated using the formula:

$$\alpha = \frac{n^* (\check{r})}{\{1+ (n-1)^* (\check{r})\}}$$ (Smith, 2003; 127)

Where:

(ř) Would be calculated from averaging $\frac{n^* (\check{r})}{\{1+ n-1)^* (\check{r})}$ correlation coefficient.

The reliability coefficient was 0.74. This falls within acceptable limits for teacher made tests of 0.7 (Ebel & Frisbie, 1991).

Item Analysis of CSCT

The procedure used to analyse test items in the CAT (3.6.1.3) was used to analyse test items of CSCT. Test items that did not reach the threshold of discrimination and difficult indices were thoroughly scrutinized for any ambiguities, inaccuracies and any other errors as advised by Lokeshkoul (1992). Mulder (1989) argues that difficulty and discrimination indices are not the only criteria for deciding the appropriateness of an item. Certain items can be retained if they deal with an important aspect of the field of investigation. For this reason that they deal with the topics prescribed in the syllabus they are retained. All the items were retained.

3.6.3 Chemistry Self-Concept Questionnaire (CSCQ)

The CSCQ (Appendix 2) contained 45 items self-report inventory designed to measure Form Three Students (age 17 years) self-concept toward chemistry. Students responded to the scale by indicating how the items apply to them. The items in the questionnaire were closed-ended questions and were measured on a 5-point Likert scale. The scale was developed by the researcher using existing scales as a guide so as to measure the subject's general or global Chemistry self-concept (see section 2.6). The scale was modified to a 5 pointer Likert- type responses instead of 7 pointer Likert- type responses (Very inaccurate 1 to very accurate 7). Modifications were done so as to reduce the number of choices for all the items making it easier for the students to make choices. The highest score in the scale is (5) while the lowest is (1) per item. For questions with a positive stem strongly agree (SA) were score highest (5) while strongly disagree (SD) were scored lowest (1). For those questions with a negative stem strongly agree (SA) were scored lowest (1) while strongly disagree (SD) were scored highest (5). The maximum scores were 230 while the minimum were 46.

For content validity of this instrument, the researcher got the opinion of 5 experts from the Faculty of Education and Community Studies at Egerton University. The questionnaire was piloted in two secondary schools (a National and a District school) outside the two counties under study. This was to ensure that students involved in piloting of the instrument had similar background as those to be involved in the study and therefore were most likely to answer the questionnaire in the same way as those to be involved in the study. Cronbach alpha coefficient was used to establish reliability of the questionnaire. Internal consistency was estimated via the split-half reliability index, coefficient alpha index (Cronbach, 1951). The appeal of an internal consistency index of reliability is that it is estimated after only one test administration and therefore avoids the problems associated with testing over multiple time periods. Cronbach coefficient alpha is typically used during scale development with items that have several response options (i.e., 1 = strongly disagree to 5 = strongly agree). A coefficient of 0.7 is considered suitable (Selltiz, Wringtsman and cook, 1976 cited in Githua, 2002). The reliability coefficient was 0.90. This falls within acceptable limits for teacher made tests of 0.7 (Ebel & Frisbie, 1991).

3.7 Data Collection Procedure

Permission was sought from the Ministry of Education Science and Technology through Egerton University before the commencement of the study. The researcher then visited the sampled schools to introduce herself to the heads of the schools and inform them of the intended study. The head then introduced the researcher to the chemistry teachers' and the form three students. Arrangements were made on when the actual study was done.

During the study the researcher with the assistance of the chemistry teachers administered the CAT, CSCT and SSCQ to the sampled streams. A total of 672 students undertook the tests CAT & CSCT and completed the SSCQ. The researcher then scored the instruments to generate quantitative data which were then analysed.

3.9 Data Analysis

Quantitative data were generated in this study which were analysed using quantitative methods of data analysis. The statistical package for social sciences (SPSS) Version 20 was used to analyse quantitative data as follows;

i. Descriptive statistics was used to describe the distribution of scores in CSCT and CAT using means, standard deviations and percentages.
ii. Inferential statistics were also used. These included t-test, Person Product Moment coefficient (PPMC), Multiple Correlations and Regression.

Summary of the analysis of data is shown in Table 2.

Table 2

Summary of Data Analysis

Hypotheses	Independent Variable	Dependent Variable	Method of Data Analysis
H_o1: There is no statistically significant difference between Boys' and Girls' scientific creativity in Chemistry Education.	Gender	Scientific Creativity in Chemistry Education	t-test
H_o2: There is no statistically significant relationship between learner's academic achievement in chemistry education and scientific creativity in chemistry education amongst Form Three chemistry students.	Academic achievement	Scientific Creativity in Chemistry Education	Pearson r
H_o3: There is no statistically significant relationship between learner's chemistry self-concept and scientific creativity in chemistry education amongst Form Three chemistry students	Learners chemistry self-concept	Scientific Creativity in Chemistry Education	Pearson r
H_o4: There is no statistically significant intercorrelations among scientific creativity in chemistry education, learner's chemistry self-concept and academic achievement amongst Form Three chemistry students	Academic achievement and Chemistry Self-concept.	Scientific Creativity in Chemistry Education	Multiple regression

CHAPTER FOUR
RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the results of the study and the discussions. Both quantitative and qualitative data were obtained and results are presented in various sections in this chapter. Results presentation is according to objectives and hypotheses of the study.

4.2 Chemistry Scientific Creativity Test (CSCT)

4.2.1 Introduction

Chemistry Scientific Creativity Test (CSCT) was used to measure the students' level of creativity in chemistry education. The (CSCT) comprised 13 test questions. The questions developed by the researcher were intended to measure the four aspects of scientific creativity (sensitivity, recognition of relationship, planning and flexibility).

4.2.2 Students' Responses and Performance on the (CSCT)

The questions were classified into categories on the basis of the creativity aspects they were measuring. However some questions were measuring more than one aspect of creativity. Students' responses and performance in each item in the (CSCT) were analysed and results are presented.

4.2.2.1 Planning Aspect

Question 1. Sandra a form 3 student in Lions Secondary School has been given 5 bottles labelled P, Q, R, S and T with colourless liquids in them. She is told that 2 of the bottles contain dilute acids, 1is an alkali and the other 2 are water. She also has a liquid indicator called phenolphthalein. This goes colourless in acids, red in alkali and colourless in water

Write some instructions for Sandra so that she can find out whether the liquid in each bottle is an alkali, acid or water. She is allowed to use a rank of test-tubes, the indicator and the liquids from the bottles P, Q, R, S and T. (10 Marks)

NB: Make sure you say exactly what she must do so that when she has finished she can label the bottles 'Acid", 'Alkali", or 'Water".

This test question was testing the planning aspect of creativity. 10 responses were expected each scoring half a mark giving a total score of 5 marks for planning.

Table 3

Expected Correct Responses

Responses
1. Put 5 clean test tubes in a rack.
2. Label them P, Q, R, S, and T.
3. Measure about 2mls of each solution and put them in the respective test-tubes.
4. Add two drops of phenolphthalein indicator in each of the test-tubes.
5. Test-tubes containing the acids and water remain colourless while the one containing alkali will turn red.
6. Label that alkali
7. Having identified the alkali, take the bottle containing the alkali and using a dropper add the alkali into the 4 test-tubes containing the other solutions.
8. Continue adding the alkali until 2 of the 4 solutions turn red while the other 2 remain colourless.
9. Label the 2 solutions that turned red Acids because they were neutralised by the base until the base changed colour with phenolphthalein
10. Label the 2 solutions that remained colourless with the addition of alkali Water

Table 4

Correct Responses from the Learners

Responses
1. Place portions of each sample i.e. P, Q, R, S and T in test-tubes
2. Put them in test-tube rack
3. Mark the test-tubes P, Q, R, S and T.
4. Add 2-3 drops of phenolphthalein indicator in each of the test-tubes
5. The test-tube with the liquid that turns red label it alkali
6. Divide the liquid identified as an alkali into 4 test-tubes
7. Add phenolphthalein indicator and mark them 1-4
8. Add drop wise the remaining four solutions in different of the four solutions of alkali e.g. P to be added in alkali1, Q tube added in alkali 2 etc.
9. The two solutions that turn the alkali liquid from red to colourless be labelled dilute acids
10. The two solutions that had no effect on alkali liquid be labelled water.

Students’ performance by gender is shown in Table 5

Table 5

Students Performance by Gender

Creativity		**GENDER**				
Aspect		**Girls**		**Boys**		
	Scores	**No.**	**%**	**No.**	**%**	**N=672**
Planning	.00	207	52.1%	163	59.7%	
	.50	12	3.2%	2	0.9%	
	1.00	30	7.7%	16	5.8%	
	1.50	29	7.4%	17	6.2%	
	2.00	42	10.6%	23	8.0%	
	2.50	40	10.0%	19	7.1%	
	3.00	22	5.2%	10	3.5%	
	4.00	8	2.0%	11	4.0%	
	5.00	8	1.7%	13	4.9%	
Total		**398**	**100.0%**	**274**	**100.0%**	

Table 5 results indicate that 18.9% of the girls scored more than half of the maximum score while 19.5% of the boys scored more than a half marks.

Question 2. Rehema complained of a burning sensation (hurt burn) along her food pipe (oesophagus) after lunch. Her chemistry teacher told her it was as a result of excessive production of hydrochloric acid in the stomach. She was advised to chew anti-acid tablets (actals). After a few minute the burning sensation stopped.

Different parts of this question measured different aspects of creativity.

a) **Explain why the burning sensation stopped after Rehema had taken anti-acid tablet. (2 marks)**

This test item was measuring the recognition of relationship aspect of creativity. Table 6 shows the expected responses.

Table 6

Expected Correct Responses

Responses
The ant-acid being a base reacted with the acid in the stomach a process called neutralisation stopping the burning sensation.

Identifying the anti-acid as a base was awarded 1 mark and for stating that neutralisation reaction took place 1 mark was awarded. The maximum score was 2 marks. Table 7 shows some of the correct responses given by the students.

Table 7

Correct Sample Responses from the Students

Responses
1. The acid reacted with the ant-acid which is a base becoming neutral therefore the burning sensation stopped due to neutralisation.
2. Ant-acid is basic and therefore it neutralises the excess hydrochloric acid.
3. The ant-acid is an alkali. It neutralised the hydrochloric acid
4. The acid is mixed (dissolved) in water thus reducing its concentration

Students' performance by gender is shown in Table 8

Table 8

Students Performance in question 2 (b) by Gender

		GENDER				
Creativity		**Female**		**Male**		
Aspect	**Scores**	**No.**	**%**	**No.**	**%**	**N=672**
RECOGNITION OF RELATIONSHIP	.00	120	30.1%	91	33.2%	
	1.00	21	5.2%	10	3.5%	
	2.00	258	64.8%	173	63.3%	
Total		**398**	**100.0%**	**274**	**100.0%**	

Table 8 indicates that the percentages of girls and boys that scored maximum score are 64.8% and 63.3% respectively. The percentage of girls who scored zero were 30.1% and that of boys was 33.2% of the boys.

b) Rehema attempted to determine the pH of the actal tablets in the laboratory to prove the answer in (a) above as follows.

- **a) She crushed the tablet**
- **b) Added ethanol to the powder and stirred with a rode**
- **c) Added phenolphthalein indicator.**

However she failed to get the pH. Suggest to her the possible mistakes that caused her to fail. (5 marks)

This test item was measuring sensitivity aspects of scientific creativity. 5 responses were expected each scoring one mark giving a total score of 5 marks for sensitivity.

Table 9

Expected Correct Responses

Responses
1. Used the wrong indicator e.g. methyl orange instead of universal indicator
2. She did not have the pH chart to read the value
3. She dissolved the tablet in the wrong solvent
4. She should have used water as a solvent
5. She did not filter or decant the mixture
6. She compared the tablet to the chart without following the correct procedure.
7. Used the wrong tablet

Each correct response was awarded one mark for sensitivity.

Table 10

Question 2 (b) Correct Sample Responses from the Students

Responses
1. Used the wrong chemicals
2. Did not follow the correct procedure
3. Used the wrong tablet
4. Failed to crush the tablet
5. Failed to make a solution

Students' performance in question 2 (b) by gender is shown in Table 11

Table 11

Students Performance in question 2 (b) by Gender

		GENDER				
Creativity		**Female**		**Male**		
Aspect	**Scores**	**No.**	**%**	**No.**	**%**	**N=672**
SENSITIVITY	0.0	67	16.9%	53	19.4%	
	1.00	155	39.0%	118	42.9%	
	2.00	124	31.2%	85	31.0%	
	3.00	45	11.2%	13	4.9%	
	4.00	4	1.1%	5	1.8%	
	5.00	3	0.6%	0	0.0%	
Total		**398**	**100.0%**	**274**	**100.0%**	

Table 11 shows that percentages of girls and boys who scored zero was (16.9%) and (19.4%) respectively. Those that scored above half were 12.9% of the girls and 6.7% of the boys. None of the boys scored the highest score of 5 marks and 2 girls (0.6%) of the girls managed to score the 5 marks.

c) Describe to Rehema how she could determine the p^H of the ant-acid tablet (actal) in the laboratory. (5 marks)

This test item was measuring planning aspect of scientific creativity. Planning aspect was measured by correct description of the steps in the procedure of measuring the pH of the tablet. Each correct step was awarded ½ a mark in the correct sequence. Incorrect sequence was not awarded marks. Any wrong response in the sequence made the rest of the responses wrong because it would not have resulted in the determination of the pH. The maximum score was 5 marks.

Table 12

Expected Correct Responses for question 2 (b)

Responses
1. Take one tablet of the anti-acid and put it in a mortar or a piece of paper 2. Crush the tablet into a fine powder 3. Put the powder in a test-tube and 4. Add some water 5. Shake the mixture vigorously 6. Allow the mixture to stand for some time for it to settle 7. Decant the solution 8. You could also filter the solution 9. Put some little solution in a test-tube 10. Add a few drops of universal indicator and shake 11. Compare the colour to the colours P^H chart 12. Read the P^H chart

Table 13 shows some of the correct responses given by the learners.

Table 13

Correct Sample Responses from the Students

Responses
1. Take the ant-acid tablet 2. Grind it using a mortar and pestle till it is smooth 3. Put the ground tablet (powder) in a beaker 4. Add distilled water until the powder dissolves 5. Add 2-3 drops of universal indicator 6. Shake the mixture well 7. Using the pH chart determine the pH value of the tablet in accordance to its colour change after adding the indicator 8. Record your results

Students' performance by gender is shown in Table 14

Table 14

Students Performance in question 2 (c) by Gender

		GENDER			
Creativity		**Female**		**Male**	
Aspect	**Scores**	**No.**	**%**	**No.**	**% N=672**
PLANNING	.00	221	55.6%	169	61.8%
	.50	18	4.6%	15	5.3%
	1.00	41	10.3%	19	7.1%
	1.50	27	7.2%	17	6.2%
	2.00	34	8.6%	15	5.3%
	2.50	32	7.7%	6	2.2%
	3.00	10	2.6%	17	6.2%
	3.50	7	1.7%	6	2.2%
	4.00	7	1.4%	5	1.8%
	4.50	0	0.0%	4	1.3%
	5.00	1	0.3%	1	0.4%
Total		**398**	**100.0%**	**274**	**100.0%**

Table 14 shows that the 55.6 % percentage of girls scored zero while 61.8% of boys scored zero in this question. (21%) of girls scored more than half the marks while only 13% of the boys score more than a half in this question. Only 0.3% of the girls and 0.4% of the boys score the maximum scored of 5.

d) Give as many as possible the importance of acid-base neutralisation. (5 marks)

This test item was measuring flexibility aspects of creativity. Flexibility was measured by how many correct responses were given. For every correct response given 1 mark was awarded. The maximum score on flexibility was 5 marks. Table 15 show the expected correct responses.

Table 15

Expected Correct Responses

Responses
1. Medical treatment of hyper-acidity
2. Farming or Agriculture. Soil treatment
3. Treatment of irritations of stings from insects
4. Prevention of diseases like ulcers
5. Sewage treatment
6. Treatment of poisonous gases
7. Production of useful salts

Table 16 shows some of the correct responses given by the learners.

Table 16

Correct Sample Responses from the Learners

Responses
1. Treatment of insect bites or wasp stings
2. Increasing soil pH
3. Reducing soil pH
4. Help in treatment of disorders like hurt burns
5. Treatment of industrial wastes before releasing them to the environment
6. Formation of useful salts
7. It is used to show end of a reaction

Table 17 shows the performance of students by gender.

Table 17

Students Performance by Gender in question 2 (d)

		GENDER				
Creativity		**Female**		**Male**		
Aspect	**Scores**	**No.**	**%**	**No.**	**%**	**N=672**
Flexibility	0.00	180	45.3	165	60.3	
	.50	57	14.3	45	16.5	
	1.00	72	18.1	37	13.4	
	1.50	37	9.7	7	2.7	
	2.00	31	7.7	11	4.0	
	2.50	14	3.4	6	2.2	
	3.00	6	1.4	2	0.9	
	4.00	0	0.0	0	0.0	
	5.00	0	0.0	0	0.0	
Total		**398**	**100.0%**	**274**	**100.0%**	

Table 17 indicates that the percentage of boys that scored zero was 60.3% while the percentage of girls that scored zero was 45.3%. Neither boys nor girls managed to score the maximum score of 5 marks. This shows that both girls and girls show low level of flexibility since they could not generate many responses to the question.

e) Rehemas mother advised her to drink plenty of water the next time she experiences the burning sensation again. Explain why drinking plenty of water stops the burning sensation.(2 marks)

This question was measuring student's ability to recognise relationship in every day context. A mark was awarded for the correct reason why there was a burning sensation and a mark for the reason why the sensation stopped after drinking water. A maximum score for the question was 2 marks. Table 18 shows the expected correct responses.

Table 18

Expected Correct Responses for question 2 (e)

Responses
1. The burning sensation is caused by concentrated hydrochloric acid in the stomach. 2. Drinking water dilutes the acid lowering its concentration in the stomach stopping the burning sensation.

Table 19 shows some of the correct responses given by the students.

Table 19

Correct Sample Responses from the Students

Responses
1. Water is neutral. The water stops the burning sensation by mixing with the acid thus forming dilute hydrochloric acid 2. Water dilutes the hydrochloric acid. The acid becomes a weak acid.

Table 20 shows students' performance by gender.

Table 20

Students Performance in question 2 (e) by Gender

		GENDER				
Creativity		**Female**		**Male**		
Aspect	**Scores**	**No.**	**%**	**No.**	**%**	**N=672**
RECOGNITION	.00	120	30.1	91	33.2	
OF	1.00	21	5.2	10	3.5	
RELATIONSHIP	2.00	257	64.8	173	63.3	
Total		**398**	**100.0%**	**274**	**100.0%**	

Table 20 indicates that the percentages of girls and boys that scored maximum score of 2 marks was 64.8% and 63.3% respectively. The percentages of girls who score zero were 30.1% and 33.2% of the boys.

Question 3. A student is trying to find out which of his two fertilizers is more enriched with nitrogen. He decided to use Ammonium sulphate and Ammonium Phosphate fertilisers on two maize plots A and B respectively.

a) If he wants it to be a fair test he will have to make sure that some things are the same for both plots. Suggest to him as many as possible things that should be the same. (5 marks)

This question was measuring planning aspect of creativity by identifying the control variables of the experiment. A 1/2 mark was awarded for each correct response. A maximum score for the question was 5 marks. Table 21 shows the expected correct responses.

Table 21

Expected Correct Responses

Responses
1. Use same amount of fertilizer
2. Use same size of plot
3. Plots to have the same type of soils
4. Plots to be in the same locality to ensure the weather will be the same
5. Plant the same number of seeds per hole
6. Plant spacing to be the same
7. The gradient of the plots to be the same
8. Plants to be grown the same time
9. Maize type (variety) to be the same
10. Same insecticides to be applied
11. Insecticide to be applied at the same time
12. If watering is to be done then it should be done same time and water amounts to be the same
13. Weeding for the crop done at the same time

Table 22 shows some of the correct responses given by the learners.

Table 22

Correct Sample Responses from the Students

Responses
1. Water supply
2. Labour in terms of weeding
3. Eradication of pests (use of pesticides)
4. Time allowance given for the two plots to yield maize
5. The number of seeds planted in the plot
6. The amount of fertilizers should be the same in the two plots
7. The fertilizer should be put in equal portion of plots
8. The two plots should be planted on the same kind of plants
9. The two plots should receive the same conditions required by the plants in the plots
10. The duration for the test should be the same
11. Both plots should experience the same environmental conditions.
12. pH of the soil in the two plots should be the same

A correct response was awarded ½ a mark. 10 correct responses were required to enable the student to score the maximum score of 5 marks. Table 23 shows the performance of students by gender.

Table 23

Students Performance in question 3 by Gender

		GENDER				
Creativity		**Female**		**Male**		
Aspect	**Scores**	**No.**	**%**	**No.**	**%**	**N= 672**
PLANNING	.00	302	75.9%	237	86.7%	
	.50	4	1.1%	4	1.3%	
	1.00	6	1.4%	2	0.9%	
	1.50	9	3.4%	6	2.2%	
	2.00	21	5.4%	7	2.7%	
	2.50	27	6.9%	7	2.7%	
	3.00	13	3.2%	5	1.8%	
	3.50	6	1.4%	1	0.4%	
	4.00	4	0.9%	4	1.3%	
	5.00	1	0.3%	0	0.0%	
Total		**398**	**100.0%**	**274**	**100.0%**	

Table 23 indicates that the percentage of the girls and boys who scored zero was (75.9%) and (86.7%) respectively. (5.5%) of girls scored more than half the marks while 2.5% of the boys scored more that the half marks in this question. This results show both boys and girls have a challenge in planning as indicated by the high percentage that scored zero.

4.2.2.2 Recognition of Relationships Aspect of Scientific Creativity

Question 4: During winter in Europe salt (sodium chloride) is poured on roads. Explain. (2 marks)

This question was used to measure recognition of relationships aspect of creativity in every day context.

Table 24

Expected Correct Responses for question 4

Responses
Ice makes the roads impassable by making the vehicles skid or slide. Salt acts as an impurity which lowers the melting point of ice leading to the melting of ice and clearing of roads.

This test item tested for recognition of relationship aspect of creativity. The scoring points in this question are; salt is an impurity for one mark and impurity lowers the melting point of ice for one mark. This gives a total score of 2 marks.

Table 25

Correct Responses from the Students

Responses
1. Salt is an impurity, when used it lowers the melting point of ice leading to the melting of ice.
2. Impurities lower the melting point of substances. Salt is used to melt the ice during winter.
3. Sodium chloride is an impurity and therefore lowers the melting point of ice thus the ice melts
4. It lowers the melting point of ice since it is an impurity making the ice melt faster
5. Salt is an impurity on ice hence it lowers its melting point and this reduces amount of snow on roads

The correct responses were awarded 2. Student's performance in this question is shown in Table 26.

Table 26

Students Performance in question 4 by Gender

Aspect of Creativity	Scores	Gender				
		Girls		Boys		
		Number	%	Number	%	N=672
Recognition of Relationship	0.0	207	52.0	150	54.9	
	1.0	133	33.4	84	30.6	
	2.0	58	14.6	40	14.5	
Total		**398**	**100.0%**	**274**	**100.0%**	

Table 26 shows that 54.9% of boys and 52% of girls did not get a mark in this question. Only 14.6 % of girls scored maximum mark of 2 marks while for boys 14.5% scored the maximum 2 marks.

Question 5. When a house newly built both the hot and cold water pipes in the kitchen was shinny. Before long, the outside of the pipes had become dull and tarnished (covered with a thick dark layer. However the outside of the hot water pipe was more tarnished than the outside of the cold water pipe.

a) What caused the pipes to tarnish? (3 marks)

This question was testing on the Recognition of Relationship aspect of creativity in classroom context. Correct response given was awarded one mark and correct explanation was awarded two marks for a maximum of 3 marks.

Table 27

Expected Correct Responses for question 5

Responses
The pipes reacted with water and air to form a hydrated oxide of iron which coated the surface of the pipes. // the pipes rusted

The correct response was awarded 2 marks.

Table 28

Correct Responses from the Learners

Responses
1. The pipes were exposed to air and moisture and thus they rusted forming the thin dark layer 2. The pipes rusted when metal reacted with air and water.

Students' performance by gender is shown in Table 29.

Table 29

Students Performance by Gender

		GENDER				
Creativity		**Female**		**Male**		
Aspect	**scores**	**No.**	**%**	**No.**	**%**	**N= 672**
Recognition of Relationship	.00	361	90.8	273	99.6	
	1.00	20	4.9	0	0.0	
	2.00	9	3.4	0	0.0	
	3.00	4	0.9	1	0.4	
Total		**398**	**100.0%**	**274**	**100.0%**	

Table 29 shows that very high Percentage of boys (99.8%) and girls (90.8%) scored zero marks in this question. Low percentages of boys (0.4%) and girls (0.9%) of girls scored the maximum score of 2 marks. This indicates that generally majority of both boys and girls were unable to recognise relationships.

b) Why do you think the hot pipe was more tarnished than the cold pipes?(2 marks)

This question was testing on the Recognition of Relationship aspect of creativity in classroom context. Correct response given was awarded one mark and correct explanation was awarded one marks for a maximum of 2 marks. The expected correct responses are shown in Table 30.

Table 30

Expected Correct Responses in question 5(b)

Responses
1. Heat in the hot water pipe accelerated the process of rusting

The correct response was awarded 2 marks. Correct responses from the learners are shown in Table 31.

Table 31

Correct Responses from the Students

Responses
1. In the hot water there is high temperature which speeds the reaction between the metal pipe and oxygen.

The performance of students in this question is shown in Table 32.

Table 32

Students Performance in question 5(b) by Gender

		GENDER				
Creativity		**Female**		**Male**		
Aspect	**Scores**	**No.**	**%**	**No.**	**%**	**N= 672**
Recognition of relationships	.00	250	71.7	155	68.6	
	1.00	53	15.2	35	15.5	
	2.00	46	13.2	36	15.9	
Total		**398**	**100.0%**	**274**	**100.0%**	

Table 32 indicates that 71.7% of the girls and 67.7% of the boys scored zero marks in this question. Only 13.2% of the girls and 15.9% of the boys scored the maximum marks.

Question 6. A student carried out an investigation of several different elements both metals and non-metals. He heated each element on flame proof paper and found the mass before and after heating. She wrote down her results in the table.

Element	**Mass before Heating in grams**	**Mass after Heating in grams**
Iron	**2.00**	**2.03**
Carbon	**2.00**	**0.2**
Sulphur	**2.00**	**0.00**
Aluminium	**2.00**	**2.02**
Copper	**2.00**	**2.03**
Iodine	**2.00**	**0.03**
Magnesium	**2.00**	**2.83**

a) If the student now heated the element Zinc and a piece of paper what would you expect to happen when heated? (2 marks)

This test question was testing on recognition of relationships aspect of scientific creativity in the classroom context. Two correct responses were expected and each scored one mark for a total of 2 marks. The expected correct responses are shown in Table 33.

Table 33

Expected Correct Responses

Responses
1. The mass of zinc will increase
2. The mass of the paper will decrease

Correct responses from the students are shown in Table 34.

Table 34

Correct Responses from the Students

Responses
1. The mass of zinc will increase
2. The mass of the paper will decrease

A mark was awarded for each of the two correct responses for a total of 2 marks.
Performance of students in this question is shown in Table 35.

Table 35

Students Performance in question 6 (a) by Gender

		GENDER				
		Female		Male		
Creativity Aspect	**Scores**	**No.**	**%**	**No.**	**%**	**N=672**
RECOGNITION OF RELATIONSHIP	.00	227	57.0	150	54.9	
	1.00	106	26.7	67	24.3	
	2.00	65	16.3	57	20.8	
Total		**398**	**100.0%**	**274**	**100.0%**	

Table 35 indicates that 57% of the girls and 54.9% of boys scored zero in this question. 16.3% of the girls got the maximum score of 2 while 20.8% of the boys got the maximum score of 2.

b) Give a reason for your answer.(2 marks)

This test question was testing on recognition of relationships aspect of creativity. The expected correct responses are shown in Table 36.

Table 36

Expected Correct Responses

Responses
1. From the table metals increase in mass when heated and since zinc is a metal then its mass will raise. 2. From the table non-metals decrease when heated and since a paper is a non-metal its mass will decrease

Correct responses generated by the students are shown in Table 37.

Table 37

Correct Responses from the Students

Responses
1. From the table metals increase in mass when heated and since zinc is a metal then its mass will raise.
2. From the table non-metals decrease when heated and since a paper is a non-metal its mass will decrease

One mark was awarded for each correct response. Student's performance is shown in Table 38.

Table 38

Students Performance in question 6 (b) by Gender

		GENDER				
Creativity		**Female**		**Male**		
Aspect	**Scores**	**No.**	**%**	**No.**	**%**	**N=672**
RECOGNITION OF	.00	351	88.3	254	93.0	
RELATIONSHIP	1.00	15	3.7	10	3.5	
	2.00	32	8.0	10	3.5	
Total		**398**	**100.0%**	**274**	**100.0%**	

Table 38 indicates that very high percentages of girls (88.3%) and Boys (93.0%) scored zero marks in this question. Those who scored the maximum score of 2 marks were 8.0% of girls and 3.5% of boys.

Question 7. During a birthday party Esther poured juice on her white skirt. She was advised to pour clean water immediately. Give a reason for the advice. (3 marks)

This question was measuring student's ability to recognise relationship aspect of scientific creativity in every day context. A mark was awarded for the 3 sections of correct response. A maximum score for the question was 3 marks. Table 39 shows the expected correct responses.

Table 39

Expected Correct Responses

Responses
1. The juice would have stained her white skirt.
2. The water would dissolve the juice and dilute it so that it does not stain the skirt.

Table 40 shows some of the correct responses given by the learners.

Table 40

Correct Sample Responses from the Students

Responses
1. So that the stain does not stick on the skirt to wash away the juice stain. Water acts as a solvent and dissolve the juice stain so that it can't be seen
2. Water would dilute the juice on the skirt making it less concentrated hence fainter in colour
3. The water would dissolve the juice as in the working of a chromatogram in the chromatography paper. The juice would dissolve forming a solution which would less likely form a stain

Students' performance is shown in Table 41

Table 41

Students Performance in question 7 by Gender

		GENDER			
Creativity		**Female**		**Male**	
Aspect	**Scores**	**No.**	**%**	**No.**	**% N=672**
RECOGNITION OF RELATIONSHIP	.00	297	74.6	219	80.1
	1.00	26	6.3	7	2.7
	2.00	65	16.4	45	16.4
	3.00	10	2.6	3	0.9
Total		**398**	**100.0%**	**274**	**100.0%**

Table 41 shows that many students 74.6% of girls and 80.1% of the boys score zero in this question. This is despite many students performing well in questions on recognition of relationship. This is because the question was not on knowledge level but on comprehension level of cognitive domain of the blooms taxonomy of leaning.

4.2.2.3 Flexibility Aspect

Question 2 (d) measured flexibility aspects of scientific creativity. The following were the other questions that were designed and used to measure flexibility aspect of scientific creativity. The responses and the performance are also given.

Question 8

a. Write as many as possible scientific uses of glass

This test item tested for the flexibility aspect of creativity. Every correct response was awarded half a mark. A sample of correct responses expected from the students is shown in Table 42.

Table 42

Expected Responses

Responses
1. Making of test tube
2. Making of telescope
3. Making of periscope
4. Making of mirrors (concave and convex and normal)
5. Heating substances in the lab
6. Holding substances in the lab
7. Making of bottles
8. Making of Thermometers
9. Making of spectacles and sun glasses
10. Making of mobile phones

A sample of correct responses generated by the students is shown in Table 43.

Table 43

Correct Responses from the Students

Responses
1. Making of test tube
2. Making of telescope
3. Making of periscope
4. Making of mirrors (concave and convex and normal)
5. Heating substances in the lab
6. Holding substances in the lab
7. Making of bottles
8. Making of thermometers
9. Making of spectacles
10. Making of mobile phone

Many other correct responses were given.

For each of the above mentioned and any other correct responses the learner scored half a mark. A maximum of 10 responses were required for the learner to get maximum score of 5 marks. Students' performance by gender is shown in Table 44.

Table 44

Students Performance in question 8 (a) by Gender

Aspect of Creativity	Scores	Gender				
		Girls		Boys		
		Number	%	Number	%	N=672
Flexibility	0.0	10	7.4	28	10.2	
	0.5	20	4.9	13	4.9	
	1.0	58	14.6	39	14.2	
	1.5	69	17.4	34	12.4	
	2.0	72	18.0	53	19.5	
	2.5	79	20.0	52	19.0	
	3.0	34	8.6	34	12.4	
	3.5	32	8.0	13	4.9	
	4.0	2	0.6	5	1.8	
	4.5	1	0.3	0	0.0	
	5.0	1	0.3	2	0.9	
Total		**398**	**100.0%**	**274**	**100.0%**	

Table 44 shows that 82.3% of the girls scored less than a half (2.5) of the total score. 70.2% of the boys score less than half score. This indicates that most girls are not able to generate many responses to a question (flexibility) like boys. One girl (0.3%) scored the highest 5 marks while the 2 boys (0.9%) scored the 5 marks. This shows that the level of flexibility aspect of scientific creativity in chemistry is low.

b. **Give as many reasons as possible why most of the laboratory apparatus are made of glass.**

This question is measuring flexibility aspect of scientific creativity. 10 responses were adequate for the award of the maximum score of 5 marks. Half a mark was awarded for each correct response for a maximum of 5 marks. A sample of the expected responses is shown in Table 45.

Table 45

Expected Responses

Responses
1. Glass is transparent hence observations can be made easily
2. Glass does not react with the chemicals
3. Glass can easily be cleaned
4. Glass can heated
5. Glass is a good conductor of heat
6. Glass does not corrode
7. Glass does not react with water
8. Easy to tell when it is dirty
9. Glass does not easily stain
10. It is beautiful

A sample of the correct responses generated by the students is shown in Table 46

Table 46

Correct Sample Responses from the Students

Responses
1. It is transparent
2. It is clear
3. Easy to clean
4. Does not react with chemicals
5. Good conductor of heat
6. Does not burn when heated

Students' performance in this question is show in Table 47.

Table 47

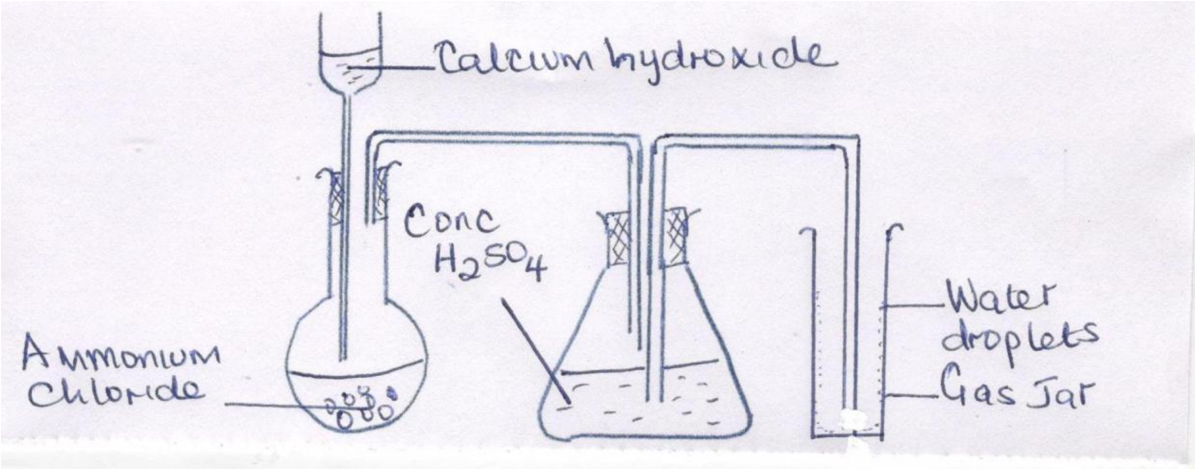
Students Performance by Gender

Creativity Aspect		GENDER				
		Girls		Boys		
	Scores	No.	%	No.	%	N=672
FLEXIBILITY	.00	207	52.1	238	59.7	
	.50	13	3.2	4	0.9	
	1.00	31	7.7	23	5.8	
	1.50	29	7.4	25	6.2	
	2.00	42	10.6	32	8.0	
	2.50	40	10.0	28	7.1	
	3.00	21	5.2	14	3.5	
	4.00	9	2.0	16	4.0	
	5.00	7	1.7	20	4.9	
Total		**398**	**100.0%**	**274**	**100.0%**	

Table 47 indicate that 52.1% of the girls and 59.7% of the boys scored zero which meant they could not generate a single correct answer. Only 1.7% of the girls and 4.9% of the boys were able to generate ten correct responses. This means the level of scientific creativity in chemistry as far as flexibility is concerned is low.

4.2.2.4 Sensitivity Aspect

Question 9. A **Form 3 student in Tumaini High school attempted to prepare DRY AMMONIA gas in the laboratory. He assembled all the apparatus as shown in the setup below. Unfortunately he did not collect any gas.**



a) **Point out to him as many as possible the mistakes that contributed to the failure of the experiment. (5 marks)**

This question was measuring sensitivity to the problem aspect of scientific creativity. Sensitivity was measured by the ability of the learner to highlight mistakes committed (1/2 a mark was awarded for each correct response). A sample of the expected correct responses from the learners is shown in Table 48.

Table 48

Expected Correct Responses

Responses
1. Using the wrong chemicals
2. Using the wrong drying agent
3. Collecting the gas by downward delivery instead of downward delivery
4. If the correct reactants were not heated.
5. He did not put the generator in a slanting position
6. Leakage from the generator through the cork
7. Use of aqueous calcium chloride instead of solid
8. Dropping funnel allowed instead of thistle funnel
9. Incorrect arrangement of the delivery tube t
10. Using of a wet gas jar and ammonia

Table 49 shows some of the correct responses generated by the learners.

Table 49

Correct Sample Responses from the Students

Responses
1.
2. He used the wrong reactants aqueous calcium hydroxide instead of solid calcium hydroxide produced no gas since the gas produced dissolved in the solution.
3. He used wrong drying agents concentrated sulphuric acid which may have reacted with ammonia conc. Sulphuric acid which reacts with ammonia to produce ammonium sulphate leading to no gas being produced
4. The generator not being in a slanting position caused the water produced run back and break the flask. Upright position causes the water produced to run back and break the generator
5. He did not collect the gas by the right method. Ammonia is less denser than air and thus should be collected by upward delivery and not downward delivery
6. He did not cork the flask hence the gas escaped to the atmosphere before he collected it.
7. Incorrect arrangement of apparatus the delivery tubes which meant even if the gas was produced it not reach the gas jar.
8. He did not close the gas jar therefore the gas escaped.
9. He may have used impure reagents meant any gas produced reacted with the impurities.
10. He forgot to heat the reactants hence the reaction with is endothermic did not take place to produce the gas.
11. He may have not given the reaction enough time hence no gas was produced
12. He used faulty apparatus which caused the gas to escape
13. There was an opening through which the gas escaped. (the corks were not tight)

Students' performance by gender is shown in Table 50.

Table 50

Students Performance in question 9 (a) by Gender

Creativity Aspect		GENDER				
		Girls		Boys		
	Scores	No.	%	No.	%	N=672
SENSITIVITY	.00	139	35.0	114	41.6	
	.50	46	11.5	13	4.9	
	1.00	46	11.5	46	11.5	
	1.50	40	10.0	46	16.8	
	2.00	72	18.1	23	8.4	
	2.50	41	10.3	27	9.7	
	3.00	8	2.0	10	3.5	
	3.50	1	0.3	5	1.8	
	4.00	4	1.1	5	1.8	
	4.5	1	0.3	0	0.0	
	5.00	0	0.0	0	0.0	
Total		**398**	**100.0%**	**274**	**100.0%**	

Table 50 indicates that 41.6% of boys scored zero in the sensitivity aspects of scientific creativity while 35.0% of girls scored zero. None of the students scored the maximum score of 5 marks in any of this aspect of scientific creativity. However the highest score obtained were 4.5 which was scored by a girl.

b. Give a reason to show how each of the mistakes mentioned above contributed to the failure of the experiment.

This question was measuring the sensitivity aspect of creativity. Each correct reason was awarded half a mark for a total of 5 marks from 10 responses.

A sample of the correct responses expected from the learners is given in Table 51.

Table 51

Expected Correct Responses

Responses
1. Using the wrong chemicals i.e. reactants that would not react to produce ammonia. Should use calcium hydroxide and ammonium chloride
2. Using the wrong drying agent e.g. sulphuric acid or anhydrous calcium that reacts with the gas
3. Collecting the gas by downward delivery. Ammonia is lighter than air hence cannot displace air upwards
4. If collected over water because it is highly soluble in water hence it will all dissolve
5. If the correct reactants were not heated. Heating decomposes the chemicals so that they react to produce ammonia
6. He did not put the generator in a slanting position which caused water produced to go back and broke the generator
7. Leakage from the generator through the cork
8. Use of dilute sulphuric acid to prepare the gas and conc. Sulphuric acid is required.
9. He may have collected the gas by over water method. Ammonia is the most soluble gas hence all of it dissolved.
10. Incorrect arrangement of the apparatus.
11. Using of a wet gas jar and ammonia being the most soluble gas it dissolved in the water
Note. Any other correct answer.

A sample of correct responses generated by the learners is shown in Table 52.

Table 52

Correct Sample Responses from the Students

Responses
1. He may have used the wrong reactants e.g. he did not use ammonium salt or more volatile base like calcium hydroxide.
2. He may have used wrong drying agent which may have reacted with ammonia e.g. conc. Sulphuric acid which reacts with ammonia to produce ammonium sulphate leading to no gas being produced
3. He may have not arranged the apparatus well, the generator in a slanting position.
4. He did not collect the gas by the right method. Ammonia is les denser than air and thus should be collected by upward delivery.
5. He may not have corked the flask for collecting the gas hence the gas escaped to the atmosphere before he collected it.
6. He did not follow the procedure keenly
7. Incorrect arrangement of apparatus
8. He did not close the gas gar therefore the gas escaped.
9. He may have used impure reagents
10. He may have forgotten to heat the reactants.
11. He may have not given the reaction enough time.
12. The reactants used may have had impurities.
13. He used faulty apparatus
14. There was an opening through which the gas escaped. (the corks were not tight)

Students' performance in this question is shown in Table 53.

Table 53

Students Performance by Gender in question 9 (b)

Creativity Aspect		GENDER				
		Girls		Boys		
	Scores	No.	%	No.	%	N=672
SENSITIVITY	.00	140	35.2	113	41.2	
	.50	42	10.5	13	4.9	
	1.00	47	11.7	34	12.4	
	1.50	40	10.0	46	16.8	
	2.00	72	18.1	22	8.0	
	2.50	40	10.0	27	9.7	
	3.00	8	2.0	10	3.5	
	3.50	1	0.3	5	1.8	
	4.00	4	1.1	5	1.8	
	4.5	1	0.3	0	0.0	
	5.00	0	0.0	0	0 .0	
Total		**398**	**100.0%**	**274**	**100.0%**	

Table 53 indicates that 41.2% of boys and 35.2% of girls scored zero in this aspect of scientific creativity. None of the students scored the maximum score of 5 marks in this question on sensitivity aspects of scientific creativity. However the highest score obtained were 4.5 which was scored by a girl.

4.3 Means and Standard Deviation by Gender on the Four Aspects of Scientific Creativity and Overall Scientific Creativity Test

For the purpose of determining the performance of students by gender in CSCT and in the 4 aspects of scientific creativity, raw scores in the CSCT were used. Questions used to compute total scores in;

- Flexibility aspect of scientific creativity were; 2d, 8a,and 8b
- Sensitivity aspect of scientific creativity were; 2b, 9a and 9 9b
- Recognition of relationship were; 2a, 2e, 4, 5a, 5b, 6a and 6b
- Planning aspect were; 1, 2c and 3

All the score in the above questions were used to compute creativity total scores.

The means and standard deviations of each of the 4 aspects of scientific creativity and the overall scientific creativity are shown in Table 54.

Table 54

Means and Standard deviation by Gender on All Aspects of Scientific Creativity and Overall Scientific Creativity Test

Aspects of Scientific Creativity	Gender	Mean	Std deviation
Flexibility	Girls	8.06	4.24
	Boys	7.19	4.74
Sensitivity	Girls	3.93	2.92
	Boys	3.58	2.53
Planning	Girls	2.75	2.70
	Boys	2.41	3.00
Recognition of Relationship	Girls	9.25	7.82
	Boys	8.35	5.38
Overall Scientific Creativity	Girls	22.60	12.73
	Boys	20.96	13.04
Total Scientific Creativity		21.92	12.93

Table 54 confirms that the mean for girls is higher than the mean for boys in all the 4 aspects of creativity under study. It is also clear that girls scored a higher mean score of 22.60% in the overall creativity than boys whose mean score was 20.96%. In addition the total scientific creativity in chemistry for both boys and girls is low 21.92%

Planning and sensitivity aspects of scientific creativity had very low mean scores. This may mean that the two aspects are not taught in classroom. It may even imply that they are not mentioned or emphasised in the syllabus and even the curriculum hence the poor performance in the CSCT. Flexibility aspect had a higher mean implying that it is taught in the classroom where students are encouraged to generate many responses to a question. However it should be noted that the students were found not capable of generating many responses in questions that required them to do so. Recognition of relationships had the highest mean score meaning that is aspect is taught in the classroom. Students were able to recognise relationship of chemistry concepts with what is taught in class (class context) and what happens outside the class (very day context). It was found out that students were more able to recognise relationships in the class context than in the everyday context.

Table 54 indicates that both boys and girls scored the highest in recognition of relationships, followed by Flexibility, sensitivity and planning got the lowest mean. However the girls scored higher means than boys in all the 4 aspects of scientific creativity. When the means scored in the four aspects of creativity were arranged in increasing order, a hierarchy in Figure 5 was generated.

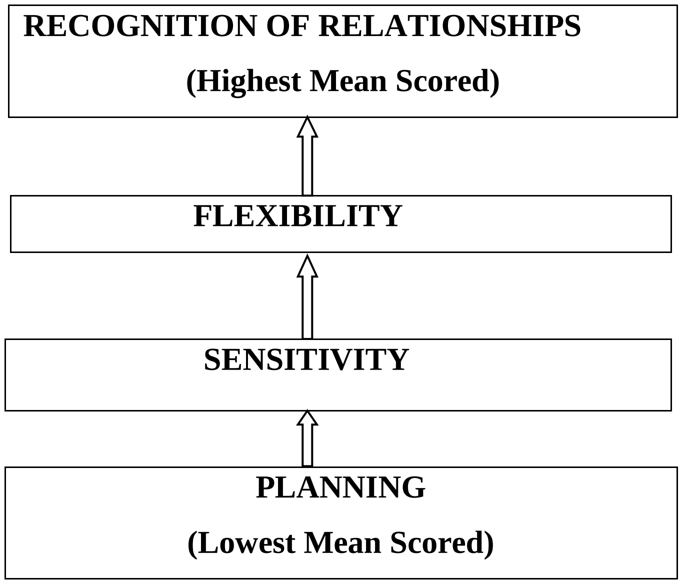


Figure 5: Hierarchical order on performance on aspects of chemistry scientific creativity

Recognition of the relationships aspect of scientific creativity is topmost in the hierarchy meaning it had the highest mean score by both boys and girls implying that it is being enhanced in the classroom. Planning is at the bottom of the hierarchy order suggesting that it was the poorest performed and not enhanced in the classroom. This hierarchy is similar to the one developed in Biology scientific creativity by Ndeke (2002) where recognition of relationship was at the top of the hierarchy followed by Flexibility, then Sensitivity and Planning at the bottom of the hierarchy order.

Sensitivity and Planning were poorly performed probably because they are not content dependent. These two aspects of scientific creativity fall under design of investigations in the scientific definitions. According to the current chemistry syllabus the two aspects of creativity are not featured or implied as seen in all the practical lessons learners are not supposed to design investigation procedure but are given the procedures for them to follow. This means the students do not acquire the skill of designing investigation so when they were asked to do so in the CSCT they could not. If students cannot plan investigations then they are unlikely to help solve problems in the society. A similar study done by Okere (1991) on high school students and first year physics undergraduate students on design of scientific experiment produced similar results of students lacking the skill. He attributed this to students either watching teacher demonstration or carrying the practical activities by merely following of the instructions without understanding what they are doing. Table 54 also confirms that the mean for girls is higher than the mean for boys in all the 4 aspects of creativity under study.

Test of significance (ANOVA –one way) was carried out in order to determine whether or not the differences in attainment between gender and various aspects of creativity were statistically significant. The results of the ANOVA (one way) are displayed in the Table 55.

Table 55

ANOVA (one-way) Result of Means Scores obtained by Boys and Girls in Various Aspects of Scientific Creativity

Aspects of Scientific Creativity		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Flexibility	Ssb	102.17	1	102.17	5.17	.023*
	Ssw	11230.03	569	19.74		
Sensitivity	Ssb	16.16	1	16.16	2.10	.15
	Ssw	4403.79	572	7.70		
Planning	Ssb	15.718	1	15.72	1.98	.16
	Ssw	4547.69	572	7.95		
Recognition of Relationships	Ssb	99.72	1	99.72	2.14	.144
	Ssw	23144.54	497	46.57		

Ssb – Sum of Squares between; Ssw – Sum of Squares within

Table 55 shows that the difference in the means scores of performance in flexibility aspect of scientific creativity of girls and boys were statistically significant at 0.05 level of significance. This is because the p-value of 0.027 is less than 0.05. t (118)= 2.221, p<0.05. On the other hand the difference in the means scores of performance in sensitivity, planning and recognition of relationships aspects of scientific creativity of girls and boys were not statistically significant at 0.05 level of significance. This is because their p-values are greater than 0.05.

Further, correlation of scores in the four aspects of creativity (planning, sensitivity, flexibility and recognition of relationships) with score of CSCT were generated and the results are shown in Table 56

Table 56

Person Product Correlation Coefficients for Learners' Scores on the Chemistry Scientific Creativity Test, Chemistry Achievement Test and Learners' scores in planning, sensitivity, flexibility and recognition of relationships Aspects of Creativity

	Flexibility	Sensitivity	Planning	Recognition of Relationship	CAT Scores	CSCT Scores
Flexibility	1	0.644**	0.733**	0.637**	0.650**	0.907**
Sensitivity	0.644**	1	0.504**	0.553**	0.511**	0.752**
Planning	0.733	0.504**	1	0.468**	0.497**	0.768**
Recognition of relationship	0.637**	0.553**	0.468**	1	0.625**	0.761**
CAT	0.650**	0.511**	0.497**	0.625**	1	0.737**
CSCT	0.907**	0.752**	0.768**	0.761**	0.737**	1

** Correlation is significant at the 0.01 level

The results in the Table 56 above indicates that the four aspects of creativity under study (Flexibility, sensitivity, planning and recognition of relationship) and CSCT are all positively correlated. Most of the correlations are high well over 0.5 with only the correlation between planning and recognition of relationship being less than 0.5. Low correlation may mean that the aspects measured different aspect of creativity while high correlation gives an indication that the two aspects measured the same aspect of creativity.

4.4 Discussion of the Results

The results in Table 56 indicate that the correlation between the students' scores in the chemistry scientific creativity and the chemistry achievement test was high (0.737) and statistically significant. This suggests that a good mastery of chemistry concepts will in turn enhance the acquisition of scientific creativity. This finding is in agreement with Okere's findings (1986) that physics knowledge contribute to creativity in physics.

Other results in table 56 show that aspects of scientific creativity correlates positively with the overall chemistry scientific creativity. This means that they measure the same construct. However the correlation between chemistry achievement test with sensitivity and planning was low compared with flexibility and recognition of relationship. Planning and sensitivity measure design of investigation on the scientific definitions of creativity, while flexibility and recognition of relationship measures generation of hypothesis. These findings suggest that chemistry knowledge contributes to performance in generation of hypothesis and not in design of investigation. This would indicate that knowledge in chemistry is not sufficient condition for one to develop skill for design of investigation. This could further suggest that one does not need to perform well in chemistry achievement test in order to learn the skill of design of investigation. These findings agree with those of Okere (1988) who found out that knowledge was contributes to performance on generation of hypothesis and not design of investigation. Similar findings were reported by Ndeke (2003).

Findings further indicated that correlation between recognition of relationship and planning was the lowest. This is explained from the fact that while planning measures the design of investigation, recognition of relationship measures generation of hypothesis. This suggests that ability to design an investigation does not necessarily develop the skill of generation of hypothesis and vice versa. This seems to further suggest that, those that perform in planning can have problem when it comes to generation of hypothesis and vice versa.

The other findings in table 56 indicated that all the four aspects of scientific creativity in chemistry were positively and significantly correlated to overall scientific creativity in chemistry. These findings are in agreement with Ndeke (2003) who found that each of the 4 aspects of scientific creativity in biology highly correlated with each other aspect of scientific creativity and with the overall biology scientific creativity test. However according to Ndeke (2003) the correlations between flexibility and planning and between flexibility and sensitivity were low while in the current study were high. The findings of this study also agree with Okere (1986) findings. However Okere's findings indicated that sensitivity aspect had a low correlation with planning unlike in the current study where the two were found to have an average correlation.

4.5.0 Creativity Level in Chemistry

Level of creativity in chemistry was measured by the Chemistry scientific creativity test (CSCT). Learners' raw scores on chemistry creativity test were expressed in percentages. The scores were then categorised into 2 categories high and low with the criterion reference of 40%. Those who scored 40% and above were categorised as highly creative, while those who scored less than 40% were categorised as having low scientific creativity. Results of this analysis are show in Table 57.

Table 57

Number and Percentage of Students and Categories of Creativity

Creativity	Number	%
High	61	9.12
Low	611	90.87
Total	672	100.00

Table 57 indicates that the level of scientific creativity in chemistry education is low since only 9.2% of all the students managed to score 40% and above in the chemistry scientific creativity test. A score of 40% and above was categorised as high level of scientific creativity. Majority of the students (90.8%) scored below 40% which was categorised as a low level of scientific creativity. From this results then it was concluded that the level of scientific creativity in chemistry education is low.

These results are in agreement with the findings of Okere and Ndeke (2012) and Hungi (2009) who found out that the level of scientific creativity in Biology were low. The findings are also in agreement with of Okere (1986)/ (1988) who found that the level of scientific creativity in Physics was low.

4.5.1 Level of Scientific Creativity by Gender.

Learners' raw scores on chemistry creativity test were expressed in percentages. The scores were then categorised into 2 categories high and low with the criterion reference of 40%. Those who scored 40% and above were categorised as highly creative, while those who scored less than 40% were categorised as having low scientific creativity. The scores were also categorised by gender. Results of this analysis are show in Table 58.

Table 58

Learners Categorized Scores by Level of Scientific Creativity and Gender

Creativity Level	**Gender**						
	Boys		**Girls**		**Total**		
	No.	**%**	**No.**	**%**	**No.**	**%**	**N=672**
High	26	8.53	39	9.82	65	9.12	
Low	249	91.48	358	90.18	607	90.87	
TOTAL	275	100 .00	397	100.00	672	100.00	

Table 58 indicates that the percentage of girls in the high category of the creativity level is higher (9.82%) than that of boys which stands at 8.53%. The total number of students in the high category of creativity is 9.12% which is lower than the percentage of girls in the high category of chemistry of scientific creativity. It also indicate that 90.87% of all the students have low level of creativity with a higher percentage of boys 91.48% having low creativity and 90.18% of the girls having low creativity level in chemistry.

An in depth analysis to show percentage of categorised scores within creativity and gender was done and results are shown in Table 59.

Table 59

Learners Percentage of Categorized Scores by Level of Scientific Creativity and Gender

			GENDER		Total
			GIRLS	BOYS	
Creativity categories	High	Number	39	26	65
		% within Creativity categories	60.0%	40.0%	100.0%
		% within Gender	9.8%	9.5%	9.7%
		% of Total	5.8%	3.9%	9.7%
	Low	Number	358	249	607
		% within Creativity categories	59.0%	41.0%	100.0%
		% within Gender	90.2%	90.5%	90.3%
		% of Total	53.3%	37.1%	90.3%

Table 59 results indicate that 60% of all the students with the high level of creativity are girls while the remaining 40% are boys. The percentage of boys with high level of chemistry scientific creativity is 9.5% which is less than the percentage of girls with high level which is 9.8%. The percentage of both girls and boys in this high level category of scientific creativity is 9.7%. It is also clear from the table that more girls were in the high level of scientific creativity than boys.

To test for the relationship between level of scientific creativity and gender Pearson Chi-square value was computed and the results are represented in Table 60.

Table 60

Relationship between Level of Scientific Creativity and Gender

SCALE		SCIENTIFIC CREATIVITY HIGH	LOW	VALUE	df	p-value	N=672
Gender	Girls	39	358	0.025	1	0.874	
	Boys	26	249				

Results in Table 60, show that 39 girls out of 397, had high level of scientific creativity in chemistry while 26 boys out of 275 boys had high level of scientific creativity. The relation between the two variables was not statistically significant, since chi-square value (χ^2) (1, N=672) = 0.025, $p > 0.05$. This indicates that there is no significant difference between boys and girls that showed high level and low levels of scientific creativity in chemistry. This shows that level of scientific creativity is not dependent on gender.

4.6 Difference in Performance in Chemistry Scientific Creativity Test by Gender

To determine if the performances in the CSCT were significantly different raw scores in test were used to calculate the mean scores by gender. The results are shown in Table 61.

Table 61

Means and Standard Deviations of the Scores Obtained by Boys and Girls in the Chemistry Scientific Creativity Test (CSCT)

Gender N=672	No.	Mean	Std deviation	Std. Error Mean
Girls	397	22.56	13.04	0.66
Boys	275	20.96	12.74	0.77
Total	672	21.93	12.93	1.04

The results in Table 61 show that girls had a higher mean of 22.59 with corresponding standard deviation of 13.03, than boys who got a mean of 20.96 with corresponding standard deviation of 12.74. This low totals mean scores of 21.93 shows that the level of chemistry scientific creativity is low.

Further analysis, test for significance (t-test, 2-tailed) for the difference in attainment of boys and girls in the entire sample was done to determine whether the difference in the mean scores of the boys and girls was statistically significant. Results are shown in Table 62.

Table 62

Test of Significance (t-test, 2-Tailed) for the Difference in Performance between Boys and Girls in Chemistry Scientific Creativity Test (CSCT)

		Levene's Test for Equality of Variances		t-test for Equality of Means				
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
CREATIVITY TOTAL SCORE	Equal variances assumed	.72	.40	1.62	670	.11	1.64	1.01
	Equal variances not assumed			1.63	597.80	.10	1.64	1.01

The difference is not significant at the 0.05 level

The result in Table 62 shows that the t value (670) = 1.62, $p > 0.05$ hence there is no statistically significant difference in the scores attained by boys and girls in the chemistry scientific creativity test. Therefore, Ho1 is retained.

4.6 Discussion of Results

Table 61 results indicate that girls had a higher mean than boys in chemistry scientific creativity test. However table 62 results show that there is no significant difference in the scores attained by boys and girls in the chemistry scientific creativity test. This implies that there is no relationship between gender and scientific creativity in chemistry education. In other words gender does not influence scientific creativity in chemistry education.

Inconsistent findings have been discovered on gender differences and creativity. These findings are in agreement with studies with younger students prior to grade three, Kogan (1974) and Tegano and Moran (1989) found a tendency for girls to score higher than boys. However, boys scored higher on originality in grade three. Coone (1969) and Warren and Luria (1972) found higher scores for girls in early adolescence on figural creativity. Likewise, Torrance (1983) found that gender differences in divergent thinking ability have changed over time. In the 1950's and 1960's boys outperformed girls on measures of originality, whereas girls surpassed boys on elaboration and most measures of verbal creativity (Torrance, 1962, 1965). Ndeke (2002) found out that in biology boys got higher mean scores than girls.

However the difference in means between boys and girls are not statistically significant meaning gender has no influence on scientific creativity in chemistry education. These results are not in agreement with findings by Ndeke (2002) and Hungi (2009) in biology and Okere (1986) / (1988) who found that there was a statistically significant relationship between scientific creativity and gender in favour of boys. They found out that in biology and physics scientific creativity was gender dependent. They also found out that the difference in scientific creativity in biology and physics was statistically significant in favour of boys.

4.7 The Relationship between Scientific Creativity in Chemistry and Academic Achievement in Chemistry

Scientific creativity in chemistry was measured by the Chemistry Scientific Creativity Test (CSCT) while the Chemistry Achievement Test (CAT) was used to measure achievement in chemistry. Learners' scores in the CSCT and CAT were expressed in percentages, means calculated then correlated. The SPSS programme was used to compute the Person Product Correlation Coefficients for the scores obtained from the two scores. The results are shown in Table 63.

Table 63

Person Product Correlation Coefficients for Learners' Scores on the Chemistry Scientific Creativity Test and Chemistry Achievement Test

		Scientific Creativity In Chemistry	Chemistry Achievement Test
Chemistry scientific creativity	Pearson correlation	1	0.731**
	Sig. (2-tailed)		0.000
	N	672	672
Chemistry Achievement Test	Pearson correlation	0.731**	1
	Sig. (2 tailed)	0.000	
	N	672	672

**. Correlation is significant at the 0.01 level (2-tailed).

The results in Table 63 show that there was statistically significant relationship between scientific creativity in chemistry education and chemistry achievement; r = 0.731**, $p < 0.05$. This implies that there is a strong relationship between academic achievement and scientific creativity in chemistry and the relationship was identified as being statistically significant at 0.05 level. This implies that a good mastery of chemistry concepts is essential for development of creativity in chemistry. Therefore, Ho2 is rejected.

4.8 Discussion of Results

The findings from Table 63 show that there was a positive correlation between the learners' scores on the Chemistry achievement and the chemistry scientific creativity test and the correlation was statistically significant. The correlation of + 0.731 is close to +1 and indicates that the two variables are strongly positively related hence score on academic achievement can be used to predict scores in chemistry scientific creativity. This suggests that high achievement in chemistry which in turn means a good mastery of chemistry of chemistry concepts is essential for effective acquisition of chemistry scientific creativity.

These findings are in agreement with findings of some researchers such as, Ai (1999); Asha (1980); Getzels and Jackson, (1962); Karimi (2000); Marjoribanks (1976); Murphy (1973);

Yamamoto (1964), Okere (1986) / (1988), Ndeke, (2003), Hungi, (2009) found that there is a relationship between creativity and academic achievement. Others like Weiner (2002) argue that the knowledge functions as a pre-requisite to creating anything while Dunbar (1999) in support to this suggests that knowledge is a pre-requisite for creative production in science.

4.9. Relationship between Students' Chemistry Self-Concept and Scientific Creativity in Chemistry Education.

The learners' raw scores in chemistry scientific creativity test and in Students self-concept Questionnaire (SSCQ) were used to compute the correlation between the two variables. The computation was done using the SPSS package version 20. The results are shown in the Table 64.

Table 64

Person Product Correlation Coefficients for Learners' Scores in the Chemistry Scientific Creativity Test and Students Chemistry Self-Concept Questionnaire

		Chemistry Scientific Creativity	Students Chemistry Self-Concept
Chemistry scientific creativity	Pearson correlation	1	0.158**
	Sig. (2-tailed)		0.000
	N	672	672
Students chemistry self-concept	Pearson correlation	0.158**	1
	Sig. (2 tailed)	0.000	
	N	672	672

**. Correlation is significant at the 0.01 level (2-tailed).

The results in Table 64 show that there is a statistically significant relationship between students chemistry self-concept and chemistry scientific creativity; $r = 0.16^{**}$, $p < 0.05$. This means that students with positive chemistry self-concept got high scores in chemistry creativity test compared to those with negative chemistry self-concept. This means that, relationship between learner's chemistry self-concept and scientific creativity in chemistry was there is a statistically significant. Therefore, Ho3 is rejected

4.10 Discussion of Results

The results in Table 64 indicate that the correlation between learners scores in chemistry creativity test and in students self-concept was positive and statistically significant. This suggests that students with positive self-concept perform better in chemistry scientific creativity test. This agrees with some theories that suggest that creativity may be particularly susceptible to affective influence. Creativity and positive affect relations according to Isen et al. (1987) has three primary effects on cognitive activity. These effects are; positive affect makes additional cognitive material available for processing, increasing the number of cognitive elements available for association; positive affect leads to defocused attention and a more complex cognitive context, increasing the breadth of those elements that are treated as relevant to the problem and positive affect increases cognitive flexibility, increasing the probability that diverse cognitive elements will in fact become associated. Together, these processes lead positive affect to have a positive influence on creativity.

Fredrickson (2001) in Broaden and Build Model suggests that positive emotions such as joy and love broaden a person's available repertoire of cognition and actions, thus enhancing creativity. Guilford (1983) argues for the existence of such a relationship between self-concept and creativity, without determining which of these variables comes before the other. This means that having a positive self-concept contributes to the emergence of the human being's creative potential. Furthermore, to the extent that the subject goes through experiences with the environment and gains creative achievements, her positive self-concept will be strengthened. Creativity and self-concept go hand-in-hand. Children with low self-concept are less likely to take the risks involved in being creative than children with healthy self-concept. Increasing self-concept can help bring a more substantial flow of creative stimulation to one's life.

4.11 Multiple Regression involving Scientific Creativity as Dependent variable and Students Self-Concept and Academic Achievement as Predictors.

This was determined by use of mean scores obtained by students in the 3 instruments in the study. These are the chemistry scientific creativity test (CSCT), student's self-concept questionnaire (SSCQ) and chemistry achievement test (CAT). CSCT was the dependent variable while SSCQ and CAT were the independent variables. H_o4 sought to find out whether students' chemistry self-concept and academic achievement had significant influence on chemistry scientific creativity.

The hypothesis was tested using the multiple regressions. Regressions procedures are used to established causal relationships between variables and also explain the power of each of the independent variable in accounting for variations in the dependent variable. The bivariate analyses were also used as they establish the strength and direction of the relationships but they do not account for the effects the predictors may have on performance (Field, 2010).

Tests for the presence of multicollinearity were performed before the multivariate statistics were conducted. Multicolinearity diagnostics were performed to test whether the independent variables are related to each other instead of being related to the criterion variable (chemistry scientific creativity). Multicollinearity was tested using tolerance and variance inflation factor (VIF) statistics. Meyers, Gamst and Guarino (2006) suggest tolerance values at .01 or less indicate the presence of multicollinearity. The results of the multicollinearity test are presented in Table 65.

Table 65

Multicollinearity Test on the Independent Variables

Independent Variables	**Collinearity Statistic**	
	Tolerance	**VIF**
Academic achievement	0.748	1.338
Chemistry Self-Concept	0.748	1.338

Results in Table 65 indicate that tolerance scores were 0.758, which far exceed the .01 threshold for multicollinearity problems. The VIF statistic is a separate colinearity diagnostic technique and is the reciprocal of tolerance. Stevens (1992) suggests VIF scores that exceed 10 indicate multicollinearity. In this study VIF scores is 1.34, which do not approach the conventional level of 10 where multicollinearity becomes a problem. Therefore, the tolerance and VIF values are well within normal bounds, indicating multicollinearity is not present among the explanatory variables. A regression analysis was done and results are shown in Tables 66 and 67.

Table 66

Model Summary of the Multiple Regressions

Model	R	R Square	Adjusted R Square	Std. Error of the Estimated
1	0.732[a]	0.535	0.534	8.605

a. Predictors: (Constant), Chemistry Achievement Test, Chemistry Self-Concept.

Table 66 results indicate that 53.4% (Adjusted R-square= 0.534) of the variation in the creativity level can be attributed to these two variables (chemistry academic achievement and self-concept in the population under study. This means that there are other factors contributing to the remaining 46.6 % influence on scientific creativity in chemistry. The correlation between the scientific creativity in chemistry and the two predictors in the sample population is 0.732 as suggested by the R value in the regression model. In addition R-square of 0.534 indicates that the model is 53.4 % effective in predicting scientific creativity in chemistry.

To test whether R-square is statistically different from zero, an ANOVA analysis was done. After the regression analysis was run its ANOVA output is shown in Table 67.

Table 67

Analysis of Variance (ANOVA) of chemistry scientific creativity and academic achievement, students' chemistry self-concept and culture.

Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
1	Regression	54106.845	2	27053.42	365.35	.000[b]
	Residual	46946.735	634	74.05		
	Total	101053.57	636			

a. Dependent Variable: Creativity Total Score

b. Predictors: (Constant), Chemistry Self-Concept, Chemistry Achievement Test scores

Table 67 results indicate that R-square was significantly different from zero, F (2, 634) = 365.35, p = 0.000. This meant that an equation relating the dependent variable to the independent variables does exist. Results further indicate that in combination the 2 independent variables (academic achievement and self-concept do predict statistically significantly the dependent variable (creativity level) because F (2, 634) = 365.35, $p < 0.05$. This is because the p-value for the Regression model F test is .000< 0.05 therefore the model is highly significant, and we can conclude that these three independent variables together predict the creativity level of students in chemistry education.

The multiple regression indicates that the two independent variable (achievement and chemistry self-concept) predicted the dependent variable scientific creativity in chemistry; F (2, 634) = 53.5, $p<0.05$. Therefore the 2 independent variables added statistically significantly to the prediction, of scientific creativity since $p < 0.05$.

The intercept (constant) and the coefficients of the independent variables (B), the t-values and the p-values were also generated during the regression analysis. A t-value and a p-value were given for the constant and each independent variable in a regression output. An independent variable is said to be a significant predictor of the dependent variables if the t-value associated with it is greater than the critical t-value. The coefficients and associated statistics are in Table 68.

Table 68

The B, t-values and p-values of the Regression Output

Scale	B	t-value	p-value
Constant	6.40	3.14	0.002
Chemistry self-concept	0.29	0.046	0.963
Chemistry Achievement	0.54	23.34	0.00

The results in the Table 68 showed that the intercept (constant) was 6.40, while the coefficients of independent variables chemistry self-concept and academic achievement were

0.29 and 0.54 respectively. Based on these results, the equation relating chemistry scientific creativity and the chemistry self-concept, chemistry academic achievement and culture was

$Y_1 = 6.40 + 0.29X_1 + 0.54X_2$

Where

Y_1 = Chemistry scientific creativity level

X_1 = Students' chemistry self-concept

X_2 = Chemistry academic achievement

The result in the Table 68 further revealed that the t-values of the independent variables academic achievement and chemistry self-concept were statistically significant except that of culture which was statistically insignificant. This meant that academic achievement and chemistry self-concept is significant predictor of the dependent variable (chemistry scientific creativity level). The following observations were made from the regression analysis:

1. The equation relating the dependent variable to the independent/explanatory variables do exist as the p-value of the ANOVA was significant
2. The model is 0.53 % effective in predicting chemistry scientific creativity in chemistry education and chemistry scientific creativity, chemistry self-concept and culture as indicated by the value of R-square
3. The regression model can be used to explain the chemistry scientific creativity level in form three students.
4. The equation can predict chemistry scientific creativity level in form three students.
    a. $Y_1 = 6.40 + 0.29X_1 + 0.54X_2$

Therefore the equation for chemistry creativity level can be written as

CSRT = 6.40 +0.29 CSCQ + 0.54 CAT.

The influence of the two independent variables (academic achievement and chemistry self-concept) on the dependent variable scientific creativity in chemistry education can be arranged as follows starting with the most influential; academic achievement > self-concept. Those with positive correlation (academic achievement) mean that they enhance chemistry after considering the other factors in the study. Those with negative correlation (culture and chemistry self-concept) mean that after considering academic achievement stifle chemistry scientific creativity in secondary school students.

The regression coefficients of the two factors are shown in Table 69.

Table 69

Intercorrelations between Chemistry Scientific Creativity Scores and Students Self-Concept, Culture and Academic Achievement Scores

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	6.40	2.036		3.143	.002
	Learners Chemistry Self-Concept	0.029	.617	.001	0.046	.963
	Chemistry Achievement Test Score	.541	0.23	.741	23.34	.000

a. Dependent Variable: Chemistry Scientific Creativity
b. Predictors: (Constant), Chemistry Self-Concept, Chemistry Achievement Test

Results from Table 69 indicate that the influence of learner's chemistry self-concept and chemistry academic achievement on chemistry scientific creativity is positive because the regression coefficients B are 0.029 and 0.541 respectively. However, the positive influence of academic achievement is high than that of chemistry self-concept since 0.541 > 0.029. It further indicates that scientific creativity in chemistry will increase by 0.029 when chemistry self-concept score increase by one holding the other independent variables (academic achievement in chemistry) constant. In addition by holding the independent variables chemistry self-concept constant the influence of academic achievement in chemistry on scientific creativity chemistry is 0.54. Furthermore it suggest that when the independent variable academic achievement scores go up by 1 mark then scientific creativity in chemistry also goes up but by 0.54 marks.

It is important to remember that the correlation between academic achievement and scientific creativity was positive (+0.731) in the bivariate model while in the above regression the B coefficient was 0.54. The difference is as a result of the multiple variable model documenting the unique effect of academic achievement on scientific creativity after counting for the other predictor variable (chemistry self-concept) in the model. On the other hand, the correlation between chemistry self-concept and creativity was positive + 0.158 in the bivalent model while in the regression the B coefficient was +0.029. The difference is as a result of the multiple variable models documenting the unique effect of learner's chemistry self-concept on scientific creativity after counting for the other predictor variable (academic achievement) in the model. Therefore the null hypothesis Ho4 is rejected.

4.12 Discussion of Results

The results in Table 69 show that the scientific creativity is influenced by chemistry self-concept and academic achievement in chemistry. The influence of chemistry self-concept and academic achievement is positive meaning increasing chemistry self-concept and academic achievement enhances scientific creativity in chemistry. It further shows that academic achievement has the highest influence then learners' chemistry self-concept while the influence of culture is the lowest. These findings are in agreement with many other studies.

Some theories suggest that creativity may be particularly susceptible to affective influence. Creativity and positive affect relations according to Isen et al. (1987) has three primary effects on cognitive activity as follows; Positive affect makes additional cognitive material available for processing, increasing the number of cognitive elements available for association; Positive affect leads to defocused attention and a more complex cognitive context, increasing the breadth of those elements that are treated as relevant to the problem and positive affect increases cognitive flexibility, increasing the probability that diverse cognitive elements will in fact become associated. Together, these processes lead positive affect to have a positive influence on creativity.

Fredrickson (2001) in her Broaden and Build Model suggests that positive emotions such as joy and love broaden a person's available repertoire of cognition and actions, thus enhancing creativity. Self-concept affects creativity. Guilford (1983) argues for the existence of such a relationship between self-concept and creativity, without determining which of these variables comes before the other. This means that having a positive self-concept contributes to the emergence of the human being's creative potential. Furthermore, to the extent that the subject goes through experiences with the environment and gains creative achievements, her positive self-concept will be strengthened. Creativity and self-concept go hand-in-hand. Children with low self-concept are less likely to take the risks involved in being creative than children with healthy self-concept. Increasing self-concept can help bring a more substantial flow of creative stimulation to one's life.

The findings of this study indicate a relationship between academic achievement and scientific creativity in chemistry. The findings are in agreement with other researchers such as, Ai (1999); Asha (1980); Getzels and Jackson (1962); Karimi (2000); Marjoribanks (1976); Murphy (1973); Yamamoto (1964), Okere (1986) / (1988), Ndeke (2003), Hungi (2009) found that there is a relationship between creativity and academic achievement.

CHAPTER FIVE

SUMMARY, CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS

5.1 Introduction

This section presents a summary of the major findings, the conclusions and implications of the findings of the study. In addition the recommendations and suggestions for further research are also given.

It further investigated the influence of gender, Academic achievement and students' chemistry self-concept on scientific creativity among form three chemistry students in the named counties. Three instruments used in the study were, Chemistry Achievement Test (CAT), Chemistry Scientific Creativity Test (CSCT) and Students Self-Concept Questionnaire (SSCQ.)

5.2 Summary of the Major Findings.

The following are the major findings of this study based on the analysis presented in Chapter Four.

I. The level of scientific creativity in chemistry education amongst form three students in the study sample was low.

II. Of the four aspects of creativity under study, recognition of relationships got the highest mean score followed by flexibility, then sensitivity and planning got the lowest mean score.

III. Girls had a higher mean score in the chemistry scientific creativity test. However difference in performance in the scientific creativity in chemistry between boys and girls was not statistically significant.

IV. Gender has no influence on scientific creativity in chemistry learning.

V. The performance of girls in all the aspects of creativity under study was better than that of boys.

VI. There was a statistically significant positive relationship between learners' achievement in chemistry and their scientific creativity in chemistry. The correlation was positive and significant ($r = 0.731$), at 0.05 level of significance.

VII. There was a statistically significant positive relationship between learners' performance in the chemistry scientific creativity test and learners' chemistry self-concept. The correlation was positive and significant (r = 0.158), at 0.05 level of significance.

VIII. Learners academic achievement has a greater influence on scientific creativity in chemistry than learners self-concept

5.3 Conclusions

Specifically, the following conclusions were reached:

I. The level of scientific creativity in chemistry education in Kenyan secondary students is low.

II. Scientific creativity in chemistry education is not influenced by learners' gender.

III. Scientific creativity in chemistry education is influenced by academic achievement in chemistry.

IV. Scientific creativity in chemistry education is influenced by learners' chemistry self-concept.

V. Academic achievement has the greater influence on scientific creativity in chemistry education than learners' chemistry self- concept.

5.4 Implication of the Findings

I. The study findings indicate that the level of scientific creativity in chemistry is low generally. This suggests that the chemistry subject syllabus objective of learners acquiring creative abilities is not being achieved. This could be attributed to teachers not inculcating scientific creativity among the learners. It could also be attributed to teachers not providing learning experiences that would encourage development of scientific creativity hence need for in- servicing of teachers.

II. The findings also indicate the gender does not influence scientific creativity. This suggests that boys and girls can acquire scientific creativity in chemistry to the same level if exposed to same chemistry content.

III. The findings of this study further pointed out that knowledge (academic achievement in chemistry) is important in enhancing scientific creativity in chemistry. Weiner (2000) argues that knowledge of what have been, generally functions as a perquisite to creating anything that has not been. This means that if chemistry teachers were to teach chemistry concept effectively and students acquired the necessary knowledge then chemistry creativity levels could be enhanced. This would involve the use of teaching methods and techniques such as creative problem solving techniques, brainstorming, experimental and learning by doing that are known to enhance creativity. According to Sommer (1961) mastery of subject matter increased along with creative ability scores as a result of weaving problem solving in the existing courses.

IV. The findings also show that chemistry self-concept also influences scientific creativity in chemistry. This suggests that if teachers were to enhance the student's chemistry self-concept this will in turn increase the level of scientific creativity in chemistry.

V. The findings further show that academic achievement and chemistry self-concept are good predictors (53.4%) of scientific creativity in chemistry. This suggests that there are other factors that predict scientific creativity hence, there is need to investigate these factors.

5.5 Recommendations of the Study

In view of the conclusions the following recommendations were made;

I. Teachers need to seek to enhance academic achievement in chemistry as this will in turn increase scientific creativity in chemistry.

II. The Ministry of Education through the Quality Assurance and Standard Officers should seek to enhance academic performance in chemistry as this will in turn increase the scientific creativity.

III. Teachers need to seek to enhance students' chemistry self-concept as this will in turn increase scientific creativity in chemistry.

IV. Secondary school administrators need to put in place approaches that will improve academic performance such as awarding the high achievers as this will in turn increase scientific creativity.

V. Kenya National Examination Council should include more test items on scientific creativity in KCSE exam.

5.6 Suggestions for Further Research

Furthers research is required to corroborate these finding, and more specifically in the following areas of concern.

I. Investigation with a lager sample involving more schools and more counties as well as more cultures in different regions of Kenya.

II. The secondary school curriculum and syllabus should be analysed to find out whether the curriculum and the syllabus has purposely made any attempt to incorporate the creative domain in science programs.

III. More studied aimed at finding the other factors contributing to the 46.7% of influence on the scientific creativity in chemistry education.

IV. Investigations should be done on the teachers understanding of scientific creativity and how to enhance it during teaching.

V. Content analysis of the KSCE examination past papers to determine if scientific creativity is examined.

VI. Studies aimed at investigating obstacles to chemistry scientific creativity development in secondary schools in Kenya.

REFERENCES

Abra, J. (1991). Gender differences in creative achievement*: A survey of Explanation Genetic, Social & General Psychology Monographs*, 117(3), 235-285.

Adams-Price, C. E. (1998), ed. *Creativity and Successful Aging*. New York: Springer.

Ai, X. (1999). Creativity and academic achievement: an investigation of gender differences. *Creativity Research Journal, 12(4),* 329-337. Available online http://www.americanscience.org 12th June 2011 1.30 pm

Albert, R. S. (1966). "*Some Reasons Why Childhood Creativity Often Fails to Make It Past Puberty into the Real World."* In Creativity from Childhood through Adulthood. New Directions for Child Development no. 72, edited by M. A. Runco, pp. 43-56. San Francisco: Jossey-Bass: Summer 1996. (EJ 534 573).

Alexander, P. A. (1992). Domain knowledge: Evolving themes and emerging concerns. *Educational Psychology*, 27, 33–51.

Amabile, T. M. (1987). *The Motivation to be Creative*. In S. G. Isaken (ed.) Frontiers of Creativity Research: Beyond the Basics (Buffalo, NY: Bearly) pp. 223–254.

Anastasi, A. (1982). *Psychological Testing*. Macmillan Publishing co. Inc. New York.

Asha, C. B. (1980). Creativity and academic achievement among secondary school children. *Asian Journal of Psychology and Education, 6,* 1-4. Available online http://www.americanscience.org

Assessment of Performance Unit (APU) (1980), *Science in Schools Age 15*: Report No. 1. (pp. 80-82). London: HMSO.

Assessment of Performance Unit (APU) (1980), *Science in Schools Age 13*: Report No. 1. (pp. 78-82). London: HMSO.

Bauer, C.F. (2005) 'Beyond "student attitudes": chemistry self-concept inventory for assessment of the affective component of student learning', *Journal of Chemical Education, 82(12),* 1864-1870.

Barron, F. (1969). *Creative Person and Creative Process.* Newyork, Holt, Rinehard and Winston.

Barron, F. and Harrington, D. M. (1981) Creativity, intelligence, and personality. *Annual Review of Psychology*, 32, 439–476.

Behroozi, N. (1997). *The Relationship between Personality, Creativity and Academic Achievement among Undergraduate Students.* University of Ahvaz, Ahvaz, Iran.

Bentley, J. C. (1966). Creativity and academic achievement. *Journal of Educational Research, 59*, 269-272.

Blacock, C.L., Lichtenstein, M.J., Owen, S., Pruski, L., Marshall, C. & Toepperwein, M. (2008). In Pursuit of Validity: A comprehensive review of science attitude instruments 1935-2005'. *International Journal of Science Education. 30(7),* 961-977.

Block, J. H. (1983). Differential premises arising from differential socialization of the sexes: Some conjectures. *Child Development, 54,* 1335–1354.

Borg, W.R. & Gall M.D. (1989). *Educational Research* (5th edition) New York, Holt, Rinehart and Winston, Inc.

Bruce, P. (1974). Reactions of preadolescent girls to science tasks. *Journal of Psychology 86(2),* 303-308.

Burt, C.C. (1962). *Critical Notice; the Psychology of Creative Ability*. In P.E. Vernon (ed). Creativity. Harmondsworth: Penguin Books Ltd, pp. 203-216.

Brunner, J. S. (1957). On-going beyond the information given? In Contemporary Cognitin, In P.E Vernon (ed). *Creativity.* Harmondsworth: Penguine Books Ltd.

Brunner, J. S. (1963). The Development of equivalent transformation in children. In P.E Vernon (ed). *Creativity.* Harmondsworth: Penguine Books Ltd.

Broc, M. A. (1994). *Rendimiento academic y autoconcepto en de education infantile y primaria*. Revista de Education.

Brown F.G. (1983). *Principles of educational and psychological testing*. 3rd Ed. New York: Holt, Rinehart and Winston.

Byrne, B.M., & Shavelson, R.J. (1987). Adolescent Self- concept: Testing the assumptions of equivalent structure across gender. *American Research Journal.*

Cattell, R. B. (1971) *Abilities: Their Structure, Growth and Action* (New York: Houghton

Charlton, B. G. (2009). Why are modern scientists so dull? How science selects for perseverance and sociability at the expense of intelligence and creativity. *Medical Hypotheses, 72(3),* 237-243.

Coopersmith, S. & Fieldman, R. (1974). *Fostering a positive self-concept & high self- esteem in classroom.* In R.H. coop & K. White (Eds.) Physiological concept in classroom. N.Y.: Haper & Row.

Coone, J.G. (1969). A cross-cultural study of sex differences in the development of selected creative thinking abilities (Doctoral dissertation, University of Georgia, 1968). *Dissertation Abstracts International, 29,* 4828B. Available online http://www.americanscience.org americansciencej@gm 112 ail.com

Cropley A.J. (1967). Creativity Educational Today. In P.E Vernon (ed). *Creativity.* Harmondsworth: Penguine Books Ltd.

Crocker, L. & Algina J. (1986). *Introduction to classical and modern test theory*. New York: Holt, Rinehart and Winston.

Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika. 16,* 297-334.

Davis, G.A. & Rimm, S. B. (1989). *Education of the gifted and talented (2nd edition).* Englewood Cliffs, NJ: Prentice-Hall Inc.

Deary, I. J., Strand, S., Smith, P., & Fernandes, C. (2007). *Intelligence and educational achievement*. Intelligence, 35(1), 13-21. Retrieved on September 9th |2011, 8.30 am from http://www.americanscience.org

De Bono, E. (1969). *The Mechanism of Mind.* ISBN 0-224-61709-5.

Durnbar, K. (1999). Scientific Creativity. The encylopaedia of creativity. Academic press, (1):1379-1384.

Ebel, R.L & Frisble, D.A. (9991). *Essentials of Educational Measurement*. Prentice Hall, Jersey.

Edwards, M. P., & Tyler, L. E. (1965). Creativity and Beyond. Available online http://www.americanscience.org editor@am 188 ericanscience.org

Espriu, R. M. (1993). *El nino y la creatividae Mexico. Trillas.*

Einstein, A. and Infield, L. (1938). *The Evolution of Physics* (New York: Simon & Schuster), p. 91.

Fennema, E., & Carpenter, T. P. (1998). New perspectives on gender differences in Mathematics: An introduction. *Educational Researcher*, *27(5*), 4-5.

Feldman, D. H. (1974). *Creativity:* Dreams, insights, and transformations. In D. H. Felman, M. Csikszentmihalyi, & H. Gardner (Eds.). Changing the world: A framework for the study of creativity (pp. 85—102). Westport, CT: Praeger.

Findlay, C. S. and Lumsden, C. J. (1988). The creative mind: Toward an evolutionary theory of discovery and innovation. *Journal of Social and Biological Structures*, *11*, 3–55.

Fraenkel, J. (2006). *How to design and evaluate research in education.* (pp. 369-395). New York, NY: McGraw-Hill.

Frankel, J.R. & Wallen, N.E. (1990). *How to design and evaluate research in education*. New York: McGraw-Hill Inc

Frazer M.J. & Sleet R.J. (1975). *Resource Book on Chemical Education in the United Kingdom*. John Wiley and Sons Ltd Publisher:

Freeman, J. (1971). *Creativity, a selected review of research*: London: Society for research into Higher Education Ltd.

Fredrickson, B.L. (2001), "The role of positive emotions in positive psychology: The broaden-and-build theory of positive emotions," *American Psychologist, 56*. 218–260.

Flaherty, M.A. (1992). The effects of holistic creativity programs on the self-concept and creativity of third graders. *The Journal of Creative Behaviour,* 26 (3), 165- 171.

Florey, J.E. & Tofoya, N. (1988). *Identifying gifted and talented American Indian students:* An overview. Las Cruces, NM: ERIC Clearinghouse on Rural Education and Small Schools. (ERIC Digest No. EDO-RC-88-14).

Gall, M.D., Borg, W.R. & Gall, J. P. *Educational Research: An Introduction*. Whiteplains, N, Y: Longman Publisher, USA.

Garrison, L. (1989) *Programming for the gifted American Indian studen*t. In C. J. Maker & S.W.

Gardner, H. (1983). *Frames of Mind.* New York: Basic Book Inc.

Garret, S. (1992). *Gender-Society Now.* Bungay, Suffolk; Richard Clay, The Chamber Press.

Gay, L., Mills, G., & Airasian, P. (2006). *Educational research: Competencies for analysis and applications.* New Jersey: Pearson Education, Inc.

Getzels, J. W. J., & Jackson, P. W (1962). *Creativity and intelligence*. New York: Wiley.

Githua, N. B. (2002). Factors Related to Motivation to Learn Mathematics Amongst Secondary School Students in Kenya’s Nairobi Province and Three District of Goals in Kenya n Schools. *Journal of Education and Human Resources*, 2 (2), 89-97

Guilford, J.P. (1983) "Creativity: Its Measurement and Development," in Parnes and Harding, *A Source Book for Creative Thinking*, Section 14, pg. 151-168.

Gottlieb, R. J. & Rogers, J. L. (200). Academic Self-Concept, Academic Achievement, and Leadership in University Students Studying in a Physical Therapy Program. *Journal of Allied Health*, 31, 99 -102.

Guilford, J.P. (1950). Creativity, In J. Freeman et al. (eds). *Creativity a selective review of research.* London. Society for research into Higher Education Ltd.

Guilford, J.P. (1959). Creativity, in J. Freeman et.al (eds) *Creativity a selective review of research*. London. Society of research into Higher Education Ltd.

Guilford, J.P. (1967). The Nature of Human Intelligence. In J. Freeman et al. (eds) *Creativity a selective of research.* London. Society for research in Higher Education Ltd.

Habibollah., N., Rohani., A., Tengku Aizan, H., & Jamaluddin, S. V., K, Mallan. (2008). Gender Differences in Creative Perceptions of Undergraduate Students. *Journal of Applied Sciences, In Press, Corrected Proof*. J.

Haddon, F. A., & Lytton, H. (1968). Teaching approach and the development of divergent thinking abilities in primary schools. *British Journal of Educational Psychology, 38,* 171-180.

Heinze, T., Shapira, P., Rogers, J. D., &Senker, J. M. (2009). Organizational and institutional influences on creativity in scientific research. *Research Policy, In Press, Corrected Proof*. J.

Hope, D. R., Smith, E. K., Crist, J. T. (1995), Reciprocal Effects of Self-concept and Academic Achievement in Sixth and Seventh Grade. *Journal of Youth and Adolescence, 24,* (295 - 314

Hu, W & Adey, P (2002). A scientific creativity test for secondary school Students. *International Journal of Science Education, 24, (4), 389–403*

Hudson, L. (1967). The question of Creativity. In P.E Vernon (ed). *Creativity* Harmondsworth: Penguine Books Ltd. Pp. 217-234

Hudson,S. E.(1990). Adaptive semantic snapping - a technique for semantic feedback at the lexical level. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 65-70. ACM Press.

Hungi, S.K. (2009) *Influence of Creativity Teaching Strategy on students' Performance and Motivation in topic Energy in Secondary School Physics in Nakuru District.* Unpublished Master's Thesis Egerton University.

Isen A.M., Daubman K.A. & Nowicki G.P. (1987). "Positive affect facilitates creative Problem solving," *Journal of Personality and a Psychology, 52*, 1122–31.

Ivcevic, Z. (2009). Creativity Map: Toward the Next Generation of Theories of Creativity. *Psychology of Aesthetics, Creativity, and the Arts*, 3(1), 17-21.

Jersild, A, T. (1952*). In search of the self.* N.Y. Teacher college press.

Kathuri, N. J. & Pals, D. A. (1983). *Introduction to Education Research*. Njoro: EMC

Karimi, A. (2000). *The relationship between anxiety, creativity, gender, academi achievement and social prestige among secondary school.* University of Shiraz, Shiraz. Available online http://www.americanscience.org americansciencej@gm 112 ail.com

Kenya National Examination Council (K.N.E.C) (2002). *2001 Kenya certificate of secondary education examination report*. Nairobi: KNEC.

Kenya National Examination Council (K.N.E.C) (2000-2002). *Kenya Certificate of Secondary Education and Syllabuse*s: Kenya National Examination Council, Nairobi.

Kelley T.L, (1939). The selection of upper and lower groups for validation of test items. *Journal of Education Psychology; 30,* 17-24.

Kogan, N. (1974). Creativity and sex differences. *Journal of Creative Behaviour, 8(1),* 1-14. Available on line http://www.americanscience.org americansciencej@gm 112 ail.com

Krause, R. (1972). *Kreativitat [Creativity]*. Munich: Goldmann. Munich: Goldmann.

Krause, R. (1977). *Produktives Denken bei Kindern (Productive thinking with children).* Weinheim, Germany. Beltz.

Kuhn, T. S. (1959) '*Tradition and Innovation in Scientific Research'*, Utah Conference on Scientific creativity.

Lau, S. & Li, W.L. (1996). Peer status and perceived creativity: Are popular children viewed by peers and teachers as creative? *Creativity Research Journal, 9(4),* 347-352.

Lau, S., & Roeser, R. W. (2008). Cognitive abilities and motivational processes in science achievement and engagement: A person-centered analysis. *Learning and Individual Differences, 18*(4), 497-504.

Lewis, M. (1990). *Self-Knowledge and Social Development in Early Life*. In L.A Pervin (ed) Handbook of Personality. 277-300, New York, Guilford.

Lokeshkoul, A. (1992). *Methodology of Educational Research.* Vikas Publishin House, PVT Ltd, New Delhi

Loehle, C. (1990) A guide to Increased Creativity in Research – Inspiration or perspiration In Garfield, E. *Current comments, Essays of an information Scientist: Journalogy* (13): 240. Institute for scientific Information. Philadephia.

Lop'ez, E and Schinitzler, E. (1983). *Factores emocionales y rendimiento Escolar.* Buenos Aires: Paidos.

Lodico, M., Spaulding, D., & Voegtle, K. (2006). *Methods in educational research: From theory to practice.* San Francisco: Jossey-Bass.

Longe, J.L (Ed). (2011). Encyclopedia of Children's Health: Infancy Through Adolescence 2nd Edition. Available online at http://www.healthofchildren.com/C/Creativity.html#ixzz3peoP3KdF

Lubart, T. I. (1994). Creativity. In R. J. Sternberg (Ed.). *Thinking and problem solving* (pp. 289-332). New York: Academic Press

Markus, H. & Nurius, P. (1986). Possible Selves. *American Psychologist Journal*. *41(1),* 954-960

MacKinnon, D. (1970). Creativity: A multi-faceted phenomenon. In J. D. Roslansky (Ed.), *Creativity: A Discussion at the Nobel Conference* (pp. 17–32). Amsterdam: North-Holland.

Mahmodi, M. T. (1998). *The Relationship between Employment's Mother, Personality, Creativity and Academic Achievement among Students in High School University of Educational' Tether*, Tehran.

Marjoribanks, K. (1976). Academic Achievement, Intelligence, and Creativity: A regression Surface Analysis. *Multivariate Behaviour Research, 11,* 105-118.

Marsh, H.W. and O'Neill, R. (1984) 'Self-Description Questionnaire III: The Construct Validity of Multidimensional Self-Concept Ratings by Late Adolescents', *Journal of Educational Measurement, 21(2),* 153-174.

Marsh, H.W. (1987). The Big-Fish-Little-Pond Effect on the Academic Self-Concept. *Journal of Educational Psychology, 79,* 280-295.

Marsh, H. W., Craven, R., & Debus, R. (1991). Self-Concepts of Young Children 5 to 8 years of Age: Measurement and Multidimensional Structure. *Journal of Educational Psychology, 83 (3),* 377-392.

Marsh, H. W, Bryne, B. M, & Yeung, A.S. (1999). Causal ordering of Academic Self-concept and Achievement: Reanalysis of Pioneering Study and Revised Recommendations. *Educational Psychologist, 34*, 154-157.

Marshall. M.S. (1971). *Analyzing Evaluation*. In A.C. Fults (Ed.) Readings in Evaluation: A Collection for Educators (pp. 3-7). Illinois, IL: The interstate Printers and Publishers Inc.

McCracken, J. L. (1998). *"Examining the Impact of Formal and Informal Learning on the Creativity of Women Inventors."* In 39TH ANNUAL ADULT EDUCATION RESEARCH CONFERENCE PROCEEDINGS, compiled by J. C. Kimmel, pp. 221-226. San Antonio, TX: University of the Incarnate Word.

Meshkani Z, Abadie H. (2005). Multivariate analysis of factors influencing reliability of teacher made tests. *Journal of Med Ed Winter. 6,* 149-159.

Mitra, N. K., Nagaraja, H. S., Ponnudurai, G. & Judson J P., (2009). *The Levels of Difficulty and Discrimination Indices in Type a Multiple Choice Questions of Pre-clinical Semester 1 Multidisciplinary Summative Tests.* 19/155B, Bukit Jalil, 57000 Kuala Lumpur, Malaysia

Mayhon, W. G. (1966). The relationship of creativity to achievement and other student variables. *Dissertation Abstracts, 27(6A),* 1713.

Meusburger, Peter (2009). *"Milieus of Creativity: The Role of Places, Environments and Spatial Contexts"*. In Meusburger, P., Funke, J. & Wunder, E. Milieus of Creativity: An Interdisciplinary Approach to Spatiality of Creativity. Springer. ISB 1402098766, 9781402098765.

Meyers, L.S., Gamst, G. and Guarino, A.J. (2006*) Applied Multivariate Research. Design and Interpretation.* SAGE Publications, Thousand Oaks.

Miller, A. L. (2007). Creativity and Cognitive Style: The Relationship between Field-Dependence-Independence, Expected Evaluation, and Creative Performance. *Psychology of Aesthetics, Creativity, and the Arts, 1(4),* 243-246.

Mooney, R. L. (1963). A conceptual model for integrating four approaches to the identification of creative talent. In C. W. Taylor & F. Barron (Eds.), *Scientific creativity: Its recognition and development* (pp. 331–340). New York: Wiley.

Mouchiroud, C., & Lubart, T. I. (2001). Children's original thinking: An empirical examination of alternative measures. *Journal of Genetic Psychology, 162(4),* 382-401.

Muijs D. (1997). Symposium: Self Perception and Performance, Predictors of Academic Achievement and Academic Self-Concept: A Longitudinal Perspective. *British Journal of Educational Psychology, 67, 263 – 277.*

Mulder, J.C. (1989). *Statistical Techniques in Education.* Gutenberg bk. Printers, Pretoria West, South Africa

Mumford, M. D., Mobley, M. I., Uhlman, C. E., Reiter-Palmon, R. and Doares, L. M. (1991). Process analytic of creative capacities. *Creativity Research Journal*, 4, 91–122.

Mumford, M.D. (2003). Where have we been, Where are we going? Taking stock in Creative research*. Creativity Research Journal*, 15, 107-120.

Murphy, R. T. (1973). Relationship among a set of creativity, intelligence, and achievement measures in a high school sample of boys. Paper presented at the Proceedings of the 81st Annual Convention, *American Psychological Association, USA, 81,* 631-632.

Naderi, H., Abdullah, R., & Tengku Aizan, H. (2008). Male versus Female National Research Council (1996). *National Science Education Standards.* Washington, DC. National Academy Press

National Research Council (1996). *National Science Education Standard*. Washington, DC. National Academy Press

Ndeke, G.C.W. (2003) *"The Effects of Gender, Knowledge and Learning Opportunities on Scientific Creativity amongst Form Three Biology Students."* Unpublished M.Ed. Thesis. Egerton University.

Nori, Z. (2002). *Gender Differences Creativity, Academic Achievement (Mathematics, Sciences and Language of Literature) among High School in City of Shiraz, Iran.* University of Shiraz, Shiraz.

Noftle, E. E., & Robins, R. W. (2007). Personality Predictors of Academic Outcomes: Big Five Correlates of GPA and SAT Scores. *Journal of Personality and Social Psychology, 93(1),* 116-130.

Ochse, R. (1990) *Before the Gates of Excellence: The Determinants of Creative Genius* (Cambridge: Cambridge University Press), p. 187.

Okere, M. I O. (1986) '*Creativity in Physics Education'*. Unplished Ph.D. Thesis, University of London.

Okere, M. I O. (1991) 'The Design of scientific Investigation by High School Pupils and First Year Undergraduates.'-*East African Journal of Education*, *1,* 73-83.

Okere, M. I O. (1996) *Physics Education*: *A Textbook of Methods for Physics Teachers.* Njoro: Egerton University, Educational Materials Centre & Lectern Publications.

Okere, M.I.O, Changeiywo, J. & Illa, T. A. (2010). Effect of Concept Teaching Strategy on Students' Creativity in Physics Education in Nyando District, Kenya. *Egerton Journal of Humanities, Social Sciences and Education, 10,* 157-170

Parners,S.J. (1963). *Education and Creativity*. In P.E Vernon (ed) Creativity. Harmondsworth: Penguin Books Ltd.

Piers, E.V. & Harris, D. (1969). *Piers-Harris Children's Self-Concept Scale.* Los Angeles CA: Western Psychology Services.

Piaget, J. (1970*). Piaget's Theory*. In P. Mussen (Ed). Wiley. New York.

Polya, G. (1957). *How to Solve it*. New York: Doubleday. Anchor Books.

Popoola, B. I. (2002). Personality Characteristics, Socuo-Demographic Variables and Work Attitudes as Correlates of counseling Effectiveness in South Western Nigeria. *Unpublished Ph.D Thesis,Obafemi Awolowo University, Ile-Ife, Nigeria.* Self-Concept and Academic Performance of Secondary School Students in Chemistry

Rathus, S. A. & Nevid J. S., (2003). *Psychology and the Challenges of Life.* 8th Ed. New York. John Willey and Sons. Inc.

Republic of Kenya, (1992). *Ministry of Planning.* Nairobi Government Printers.

Republic of Kenya, (2007). *Ministry of Planning and National Development*. Nairobi Government Printers.

Republic of Kenya, (2009). *The Report of the National Committee on Educational Objectives and Policies.* Nairobi Government Printers.

Republic of Kenya, (2010). *The Report of the National Committee on Educational Objectives and Policies.* Nairobi Government Printers.

Rogers, C. R. (1954) 'Towards a Theory of Creativity'. *A Review of General Semantics*, 11, 249-260.

Rosenberg, M., Schooler, C., & Schoenbach, C. (1989). Self-esteem & adolescent Problem. Modelling reproach effect. *American Sociological Review, 54,* 1004-1018

Runco, M. A. (1991) *Divergent Thinking* (Norwood, NJ: Ablex).

Runco, M. A. (2007a). *Cognition and Creativity*. In Creativity (pp. 1-38). Burlington: Academic Press.

Runco, M.A., Pritzker, S. R. (Ed.). (2011). Encyclopedia of Creativity (2nd ed., Vols. 1-2). Academic Press; Available on line at http://www.amazon.com/Encyclopedia-Creativity-Two-Volume-Second-Edition/dp/0123750393

Sanchez, F. J. P. and Roda, M. D. S., (2005). Relationship between Self-Concept and Academic Achievement in Primary Students. *Electronic Journal of Research in Educational Psychology and Psych pedagogy,* 1910, (2005), 95 – 120.

Shavelson, R.J, & Bolus, R. (1987). Self-concept. The Interplay of theory & Methods. *Journal of Education Psychology, 79,* 3-17.

Shin, S. H., & Jacobs, S. S. (1973). An analysis of the interrelationships among intelligence and multilevel of creativity and achievement. Paper presented at the Proceedings of the 81st Annual Convention, *American Psychological Association, USA, 81,* 629-630.

Si-Mui S, & Rasiah R.I (2006). *Relationship between Item Difficulty and Discrimination Indices in True/False Type Multiple Choice Questions of a Para-Clinical Multidisciplinary Paper.* Ann Acad Med Singapore; 35: 67-71.

Simonton, D. K., & James, E. B. (2007). Creativity. In *Encyclopedia of Gerontology* (pp. 316-324). New York: Elsevier.

Sierwald, W. (1989). *Creative hochbegabung-Identiflkation, entwicklung undforderung kreativer hochbegabter (Creative talent: Identification, development, and demand).* Paper presented at the Paper presented at the 2nd Meeting of the Section Educational Psychology of the German Psychological Society

Smith, I. L. (1971). I.Q., creativity and achievement: Interaction and threshold. *Multivariate Behavioural Research, 6,* 51-62.

Sommers, W.S. (1961). The influence of selected teaching methods on the development of creative thinking. In P.E. Vernon (ed). *Creativity.* Harmondsworth: Penguine Book Ltd.

Sternberg, R. J., & Lubart, T. I. (1992). Creativity: Its nature and assessment. *School Psychology International, 13(3),* 243-253.

Sternberg, R. J. (1996) *Successful Intelligence* (New York: Basic Books).

Steinmayr, R., & Spinath, B. (2009). *The Importance of Motivation as a Predictor of School Achievement.* Learning and Individual Differences, 19(1), 80-90.

Stevens, J.P. (2009). Applied Multivariate Statistics for Social Sciences (5th ed). New York. Routledge.

Tanpraphat, A. (1976). *A Study of the Relationship between Creativity, Academic Achievement, Scholastic Aptitude, Sex, and Vocational Interests of Tenth Grade Thai Students.* University of North Colorado, Greeley.

Theodore, P (Ed). (2002). Britanica Concise Encyclopaedia (1st ed) Updated Version. Encyclopaedia Britannica, Incorporated; London: Available online at http://*www.amazon.com*

Tegano, D.W. & Moran, J.D. (1989). Sex differences in the original thinking of preschool and elementary school children. *Creativity Research Journal, 2(1-2),* 102-110.

Thorndike, R.L & Thorndike, R.M (1994). Reliability in Education and Psychological Measurement. In Husen T. & Postleth-Waite T.N. (Eds.) *The International Encyclopaedia of Education* vol. Ix 2nd Edition (4991-4992) Boulevard: Pergamon.

Torrance, E. P. (1990). *The Torrance Tests of Creative Thinking Norms—Technical Manual Figural (streamlined) Forms A & B.* Bensenville, IL: Scholastic Testing Service, Inc

Torrance, E. P. (1959). *Explorations in Creative Thinking in the Early School Year: VI. Highly Intelligent and Highly Creative Children in a Laboratory School Minneapolis:* Bur. Edu. Res. University of Minnesota.

Torrance, E.P (1961). Status of Knowledge Concerning Education and Creativity Scientific Talent. Work Paper for a project on the status of Knowledge about Creative scientific talent, directed by Calvin W, Taylore, University of Utah, with support by the National Science Foundation. In P. E. Vernon (ed) *Creativity.* Harmondsworth Penguine Book Ltd.

Torrance, E.P (1962). *Guiding Creative Talent.* In P. E. Vernon (ed). Creativity. Harmondsworth: Penduin.

Torrance, E.P. (1963). *Education and the Creative Potential*. Minneapolis, MN: University of Minnesota Press.

Torrance, E.P. (1965). *Rewarding Creative Behaviour*. Englewood Cliffs, NJ: Prentice Hall.

Torrance, E.P. (1974). *Torrance Tests of Creative Thinking.* Personnel Press. Von Franz, Marie-Louise, Psyche and Matter (Shambhala, 1992) ISBN 0-87773-902-1

Torrance, E.P. (1983*).* Status of Creative Women: Past, Present, and Future. *Creative Child and Adult Quarterly, 8(3*), 135-144.U.S. Department of Education (1991)

Trautwein, U., Ludtke, O., Marsh, H.W., Koller, O. and Baumert, J. (2006) 'Tracking, Grading and Student Motivation: Using Group Composition and Status to Predict Self-concept and Interest in Ninth Grade Mathematics', *Journal of Educational Psychology,* 98(4), 788-806.

Treffinger, D., Young, G., Selby, E & Shepardson C. (2000). *Creative Problem Solving*. An introduction. (3rd Edition). New York, NY: Sarasota, Inc.

Treffinger, D. (2001) (Ed). *Creative Learning Today*. New York, NY: Sarasota, Inc.

Treffinger, D. (2002). *The Need for Balance: We should Think 'Process And Content'. Not Process Versus Content.* New York, NY: Sarasota, Inc.

Treffinger D.J. et al. (2001). *Creative Problem Solving.* An introduction. (3rd Ed). TX Waco: USA Prufrock Press.

Treffinger, D. et al. (2001) Definitions and characteristics of Creativity and Creative Thinking. In Treffinger, D. (Ed). *Creative Learning Today*. Centre for Creative Learning. Sarasota, FL:

Treffinger, D. et al. (Ed) (2001). *Key Element of the Talent Development Journey*. Creative Learning. Centre for Creative Learning. Sarasota, Inc.

Treffinger, D. et al. (Ed)(2002). *Creativity and Life's Challenges*. Centre for Creative Learning. Sarasota. U.S.A.

Wachanga, S.W. (2002). *Effects of Cooperative Class Experiment Teaching Method on Secondary School Students' Motivation and Achievement in Chemistry.* Unpublished Ph.D Thesis, Njoro: Egerton University.

Wallach, M., & Kogan, N. (1965). *Modes of Thinking in Young Children*. New York: Holt, Rinehart & Winston.

Warren, G.H. & Luria, Z. (1972). Evaluational Set and Creativity. *Perceptual Motor Skills, 1(2)*, 436-438.

Washton, N. S. (1966) 'Teaching Science for Creativity': *Science Education, 50,* 22-83.

Welsch, P. K. (1981). The nurturance of creative behavior in educational environments: A comprehensive curriculum approach. *Dissertation Abstracts International, 41*(09), 3870A (University Microfilms No. 81-06456).

Weiner, R.P. (2000). *Creativity and Beyond*. State University of New York Press, Albany.

Williams, F. (1980). *Creativity Assessment Packet*: Manual. East Aurora, NY: DOK Publishers.

Wylie R. C. (1961). *The Self Concept: A Critical Survey.* Book.google. com>Psychology>General. Htt://book.google.com/book/about/The self concept.html? Id=QZHAAAAMAAAJ. University of Nebraska Press 1961-Psychology

Yamamoto, K. ((1964)). A further analysis of the role of creative thinking in high school achievement. *Journal of Psychology, 58*, 277-283.

Yusuf, S. (2009). From Creativity to Innovation. *Technology in Society, 31(1),* 1-8.

Zahran, H.A.S. (1967). 'The self-concept in the psychological guidance of adolescents'. *British Journal of Educational Psychology, 37,* 225-239

Zeger's, B. (1981). *Proposicion de un Modelo Anilitico de la psicologia de si mismo.* Revista de Estudios Sociales.

APPENDICES

APPENDIX A: CHEMISTRY SCIENTIFIC CREATIVITY TEST (CSCT)

NAME
SCHOOL
FORM THREE
INSTRUCTIONS

ANSWER ALL THE QUESTIONS IN THE SPACES PROVIDED

1. FLEXIBILITY

Write down as many as possible scientific uses as you can for a piece of glass. (10Marks).

....

....

....

....

....

....

....

2. RECOGNITION OF RELATIONSHIPS.

During winter in Europe salt (sodium chloride) is poured on roads. Explain. (3 marks)

....

....

....

3. RECOGNITION OF RELATIONSHIPS.

When a house was newly built both the hot and cold water pipes in the kitchen was shinny. Before long, the outside of the pipes had become dull and tarnished (covered with a thin dark layer. The outside of the hot water pipes was more tarnished than the outside of the cold water pipe.

a) What caused the pipes to tarnish?(4 marks)

....

....

b) Why do you think the hot water pipe was more tarnished than the cold water pipes? (2 marks)

....

....

....

....

c) What substance do you think the tarnish is made of? (2 marks)

....

4. PLANNING FOR INVESTIGATION. Sandra a form 3 student in Lions Secondary school has been given 5 bottle labelled P, Q, R, S, and T with colourless liquids in them. She is told that 2 of liquids are dilute acids, 1 is an alkali and the other 2 are water. She also has a liquid indicator called phenolphthalein. This goes;

- Colourless in Acids
- Red in Alkali
- Colourless in Water.

Write some instructions for Sandra so that she can find out whether the liquid in each bottle is an acid, alkali or water. She is allowed to use a rack of test-tubes, the indicator and the liquids from the bottles P, Q, R, S, and T.(5 marks).

NB: Make sure you say exactly what she must do so that when she has finished she can label the bottles 'Acid", 'Alkali", or 'Water".

----

3. (RECOGNITION OF RELATIONSHIP A student carried out an investigation of several different elements both metals and non-metals. He heated each element on flame proof paper and found the mass before and after heating. She wrote down her results in the table.

Element	Mass before Heating in grams	Mass after Heating in grams
Iron	**2.00**	**2.03**
Carbon	**2.00**	**0.2**
Sulphur	**2.00**	**0.00**
Aluminium	**2.00**	**2.02**
Copper	**2.00**	**2.03**
Iodine	**2.00**	**0.03**
Magnesium	**2.00**	**2.83**

a) If the student now heated the element Zinc and a piece of paper what would you expect to happen when heated? (2 marks)

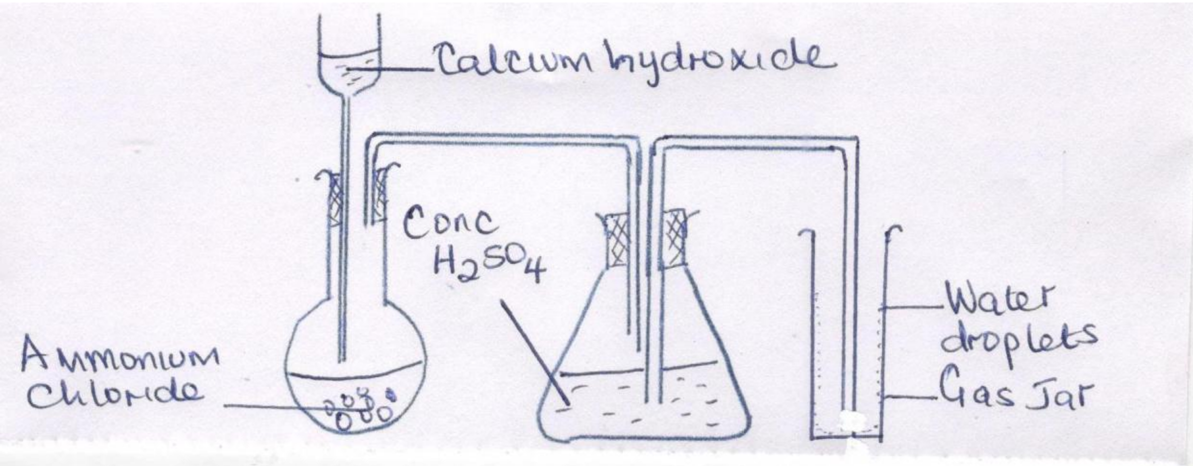
----

b) Give a reason for your answer.(2 marks)

----

5. SENSITIVITY ASPECT

Question 1. A **Form 3 student in Tumaini High school attempted to prepare DRY AMMONIA gas in the laboratory. He assembled all the apparatus as shown in the setup below. Unfortunately he did not collect any gas.**



b) Point out to him as many as possible the mistakes that contributed to the failure of the experiment. (5 marks)

....

....

....

....

....

....

....

b.Give a reason to show how each of the mistakes mentioned above contributed to the failure of the experiment.

----

6. **PLANNING FOR INVESTIGATION & RECOGNITION OF RELATIONSHIPS.**
Rehema complained of a burning sensation (hurt burn) along her food pipe (oesophagus) after lunch. Her chemistry teacher told her it was as a result of excessive production of hydrochloric acid in the stomach. She was advised to chew anti-acid tablets (actals). After a few minute the burning sensation stopped.

f) Explain why the burning sensation stopped after taking anti-acid tablet. (2 marks)

----

g) Rehema attempted to determine the p^H of the actal tablets in the laboratory to prove the answer in (a) above. However she failed to get the p^H. Suggest as many as possible the mistakes Rehema did that made the experiment to fail. (10 marks
....
....
....
....
....
....
....

h) Give as many as possible the importance of acid-base neutralisation. (10 marks)
....
....
....
....
....
....
....
....
....

....
....

7. **PLANNING FOR INVESTIGATION** A student is trying to find out which of his two fertilizers is more enriched with nitrogen. He used **Ammonium sulphate** and Ammonium **Phosphate** fertilisers on two maize plots A and B.

a) If he wants it to be a **fair test** he will have to make sure that some things are the same for both plots. Suggest to him as many as possible things that should be the same. (10 marks)

....
....
....
....
....
....
....

b).Describe how the whole test would be carried

....
....
....
....
....
....
....
....
....
....

8. FLEXIBILITY AND RECOGNITION OF RELATIONSHIPS

Chemistry students from Tumaini House School last holiday visited Mombasa on a school trip. John a form 3 student noted that most of the houses roofed with iron sheets were seriously corroded and were brown in colour. When John talked to the residence on the same he was told that iron sheets corrode very fast in Mombasa.

i. Explain to John why iron sheets corrode very fast in Mombasa. 4marks)

....
....
....
....
....
....

ii. Explain to John ways through which the corrosion can be prevented or slowed down. (6 marks)

....
....

....
....
....
....
....

10. **PLANNING FOR INVESTIGATION & RECOGNITION OF RELATIONSHIPS.**

A farmer had two types of soils, acidic and basic soils. He wanted to find out which of the two soils is best for planting cabbages. Describe how he would do this. (10 marks)

....
....
....
....
....
....
....
....
....
....
....

APPENDIX B: STUDENTS CHEMISTRY SELF- CONCEPT QUESTIONNARE (SCSCQ)

(THE WAY I FEEL ABOUT CHEMISTRY SUBJECT)

INTRODUCTION

My name is Florence a student at Egerton University. I am undertaking research in chemistry education and I have selected you to participate in the study. All the responses will be kept confidential and the information given will only be used for this research purpose.

Part A: Demographic Data

1. Name ___________________________________

2. Name of the school _________________________

3. Category of the primary school (Check (✓) one.

(a) National ________________ (b) District ___________________

4. Type of schools social set up (Check (✓) one.

(a) Boys only.________________

(b) Girls only.____________________

(c) Mixed (Co-Educational) _____________________

Instructions

Here are some statements that tell how people feel about Chemistry Subject. Listen to each statement carefully & decide whether or not it describes the way you feel about Chemistry Subject. Select one of the five responses next to each statements and show how exactly the extent to which you agree with the statement in relation to your feeling. Make sure the responses you have chosen describes the way you feel about Chemistry Subject. If you strongly agree choose the letter SA, if you agree choose the letter A, if you are undecided or uncertain choose chose letter U , if you disagree chose letter D if you strongly disagree choose letter SD. Respond to every statement even if someone had to decide . Choose only one response for each statement; remember there are no right or wrong answers. It is only you who tell how you feel about Chemistry Subject. So I hope you will respond the way you really feel inside yourself about Chemistry Subject.

KEY:

Strongly agree	Agree	Undecided	disagree	Strongly disagree
SA	A	U D	D	SD

STATEMENT	SA	A	UD	D	SD
1. I find many math problems in chemistry difficult.					
2. I find chemistry interesting.					
3.I am never able to think up answers to problems in Chemistry.					
4. I have never been excited about chemistry.					
5. I have hesitated to take subjects that involve chemistry concepts.					
6. I hate chemistry.					
7. I am good at combining ideas from various topics in chemistry					
8. I participate confidently in discussions with school friends about chemical topics.					
9. I have generally done better in chemistry subject than any other subject					
10. I like chemistry subjects.					
11. I find organic chemistry concepts interesting.					
12. I find chemistry concepts difficult.					
13. Chemistry makes me feel inadequate					
14. I have trouble with the MOLE CONCEPT topic in chemistry.					
15. I enjoy doing experiments during practical lessons in chemistry.					
16. When I run into chemistry revision books or papers during my private studies I always do them.					
17. I am quite good in chemistry.					
18. I'm good at most topics in chemistry.					
19. I'm not good at practical's in chemistry.					
20. I would hesitate to enrol in courses that involve Chemistry.					
21. I have trouble understanding anything based on chemistry.					
22. I'm not particularly interested in most topics in chemistry subject.					
23. I have a lot of intellectual curiosity in chemistry concepts.					

	SA	A	U	D	SD
24. I am quite good at dealing with chemical ideas.					
25. I have always done well in titration questions.					
26. I learn quickly in most academic subjects.					
27. I am not very interested in applying chemistry knowledge outside the school.					
28. Chemistry intimidates me.					
29. I never do well on tests that require chemistry reasoning.					
30. I hate writing symbols and formulae of compounds in chemistry.					
31. I have always found chemistry knowledge highly relevant in day today life					
32. I have always had difficulty understanding arguments that require chemical knowledge.					
33. At school, my friends always come to me for help in chemistry.					
34. I am confident I will do very well in chemistry in KCSE					
35. I would represent my in a chemistry interschool Symposium or competition.					
36. I would have no interest in a career requiring chemistry knowledge.					
37. I have always applied chemistry knowledge at home.					
38. I have never been very excited about chemistry.					
39. I could never achieve academic grade A in chemistry, even if I worked harder.					
40. I enjoy writing and balancing chemical equations.					
41. I have trouble understanding anything based on chemistry.					
42. I dislike my chemistry teacher					
43. Given an option I would drop chemistry subject					
44. I find structures of organic compounds unrealistic					
45. I enjoy doing home work form most topics in chemistry.					

APPENDIX C: CHEMISTRY ACHIEVEMENT TEST (CAT)

Name:……………………………………………

School………………………………………………

Answer all the questions in the spaces provided.

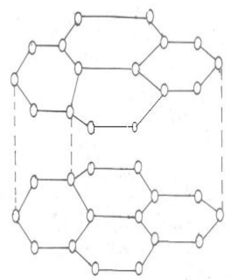
1 a) What is meant by allotropy? (1 mark)

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………

b) The diagram below shows the structure of one the allotropes of carbon



i) Identify the allotrope (1mark)

……………………………………………………………………………………………

………………………………………………………………………………………

ii) State one property of the above allotrope and explain how it is related to its structure (2mark)

…………………………………………………………………………………………

2. Pentane and ethanol are miscible. Describe how water can be used to separate a mixture of pentane and ethanol (3mks)

……………………………………………………………………………………………

……………………………………………………………………………………………

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

....

3. a) Using dots and cross diagram, show how a hydro-axonium ion, H_3O^+ if formed hint : $H_2O+H^+ \rightarrow H_3O^+$ Atomic numbers (H=1, O=8) (2mks)

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………

b) What name is given to the bonding in (a) above? (1mk)

………………………………………………………………………………………………

5. 60cm of oxygen gas diffuses through a porous hole of 50 seconds. How long wills it take 80cm of sulphur IV oxide to diffuse through the same hole under the same conditions. (S=32, O=16) (3mks)

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………

7. a) Draw and name the structure of the compound formed when one mole of ethyne reacts with one mole of hydrogen bromide (2mark)

b) Draw and name the structural isomer of $C_4 H_8$. (2mks)

8. The table below gives the atomic numbers of element X, Y and Z. The letters do not represent the actual symbols of elements.

Element	W	X	Y	Z
Atomic number	9	10	11	12

a) Which one of the elements is least reactive? Explain? (2mk)

…………………………………………………………………………………………………

…………………………………………………………………………………………………

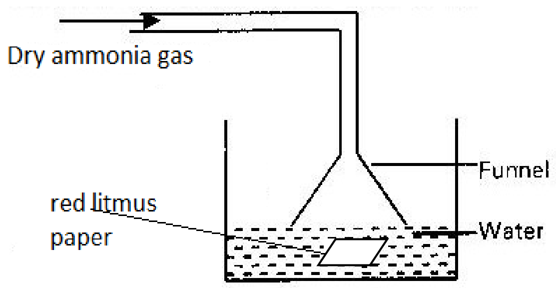
…………………………………………………………………………………………

b) i) Which one of the element would react most vigorously with each other?(1mk)

………………………………………………………………………………………………

ii) Give the formula of the compound formed when elements in i) above react. (1mk)

9. Dry ammonia was made to dissolve in water using the set of apparatus shown below



c) What is the use of inverted funnel (1mark)

…………………………………………………………………………………………………

…………………………………………………………………………

d) Give and explain the observation made on litmus paper (1mark)

…………………………………………………………………………………………………

…………………………………………………………………………………………………

……………………………………………………………………………………………

11. The following are the observations made from two solid substances X and Y

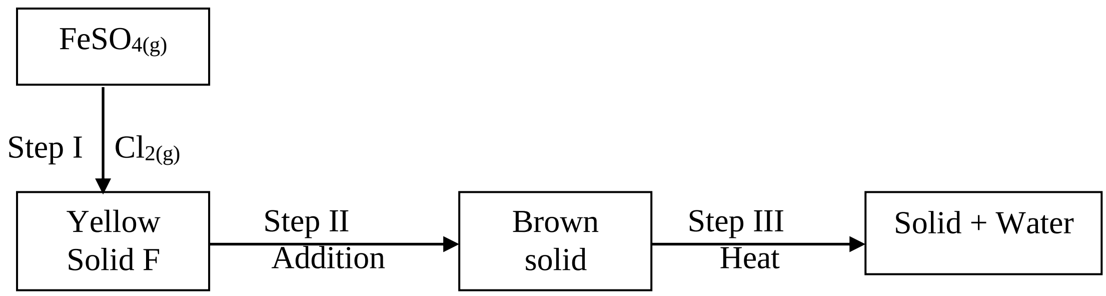
solid	Electrical conductivity in solid state	Solubility in water	Boiling point
X	Poor	Insoluble	Sublimes
Y	Poor	soluble	High

State the most likely type of bonding in

i) Solid X…………………………………………………………… (1 mark)

ii) Solid Y…………………………………………………………… (1mark)

13. Study the scheme below and answer the questions as follows.



i) Write down the formula of the yellow solid F. (1mark)

…………………………………………………………………………………………

ii) Write property of chloride is shown in step I (1mark)

……………………………………………………………………………………………

………………………………………………………………………………

iii) Write an equation for the reaction which occurs in step III (2mark)

……………………………………………………………………………………………

………………………………………………………………………………

14. When air is bubbled through pure water (PH=7) the PH drops to 6.0. Explain. (2mks)

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………

15. Distinguish between isotopes and allotropes. (2mks)

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………

17. Calculate the mass of sulphur which on complete combustion would yield 7dm^3 of sulphur IV oxide measured at 182^{0}c and 722mm Hg pressure
(O=16, S=32, molar gas volume = 24dm^3 at r.t.p.) (3marks)

19. a) Differentiate between alcohols and hydrocarbons. (2mark)

……………………………………………………………………………………………

……………………………………………………………………………………………

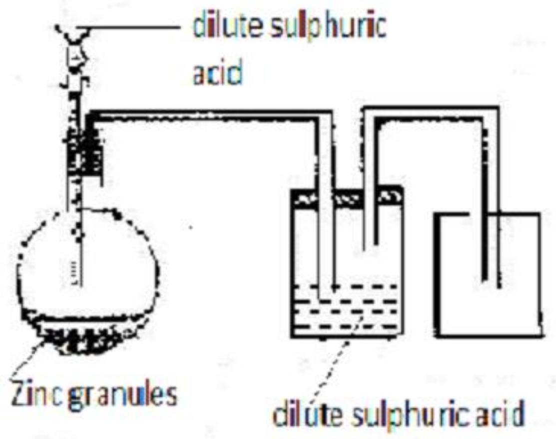
…………………………………………………………………………

b) In the test for chlorides ions in solution, a little nitric is added followed by silver nitrate solution, why nitric added. (1mark)

……………………………………………………………………………………………

………………………………………………………………………………

20. The set up below shows laboratory preparation of hydrogen gas use it to answer the questions that follow.



a) Identify two mistakes in the set-up (2marks)
....
....
....
....

b) Why is dilute nitric acid not used in preparation of hydrogen gas. (1mark)

…………………………………………………………………………………………

………………………………………………………………………………………

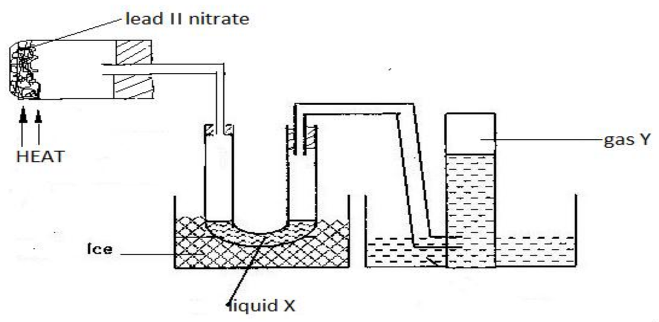
21. Starting with copper II oxide, describe how you can prepare copper II sulphate crystals (4marks)

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………

22. The set-up below shows the products formed when solid lead (ii) nitrate is heated.



a) Identify:

i) Liquid X…………………………………………………………………. (1mark)

ii) Gas Y …………………………………………………………………(1mark)

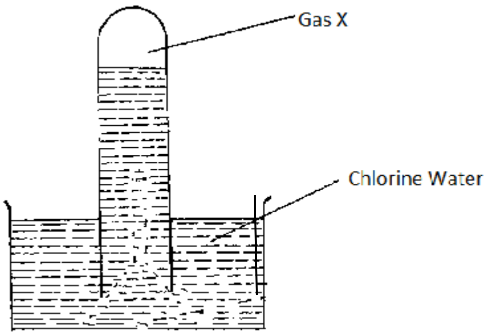
b) When Lead(II) nitrate crystals are heated, they decrepitates and decompose, what is meant by the term decrepitating (1 mark)

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………

23. Study the set-up below and answer the questions that follow



a) Name gas …………………………………………………………(1mark)

b) State the condition which is not indicated on the diagram for gas X to be formed (1mark)

…………………………………………………………………………………………

……………………………………………………………………………

c)Write the chemical equation for the reaction taking place in the set-up above. (2marks)

24. Aluminium chloride sublimes. Explain why this is possible (2marks)

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………………………

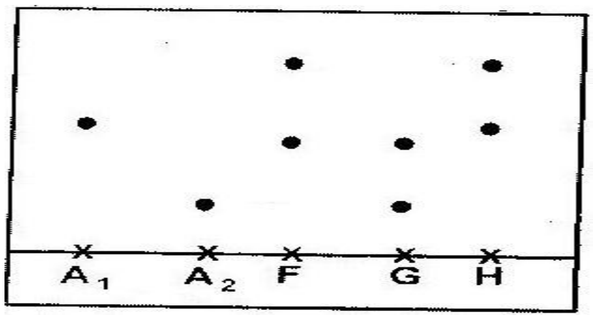
25. State how burning can be used to differentiate between but-1-yne and butane. (2marks)

…………………………………………………………………………………………

…………………………………………………………………………………………

……………………………………………………………………………

26. Samples of urine from three participants F, G and H at an international sports meeting were spotted onto a chromatography paper alongside two from illegal drugs A_1 and A_2. A chromatogram was run using methanol. The figure below shows the chromatogram.



a) Identify the athlete who had used an illegal drug. (1mk)

....

b) Which drug is more soluble in methanol? Explain your answer.(2mks)

………………………………………………………………………………………………

………………………………………………………………………………

c) On the diagram show the solvent front and the base line. (2mks)

e) Which of the drug has the highest density? Explain your answer. (2mks)

....

....

....

27.a) Give the observation made when ammonia gas is passed over hot platinum wire in the presence of oxygen gas (1mark)

………………………………………………………………………………………………

……………………………………………………………………………………………

b) Write chemical equation(s) for the reactions taking place (a) above (2marks)

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………

28. State and explain the observations made when fluorine gas is bubbled through sodium bromide solution (2marks)

………………………………………………………………………………………………

………………………………………………………………………………………………

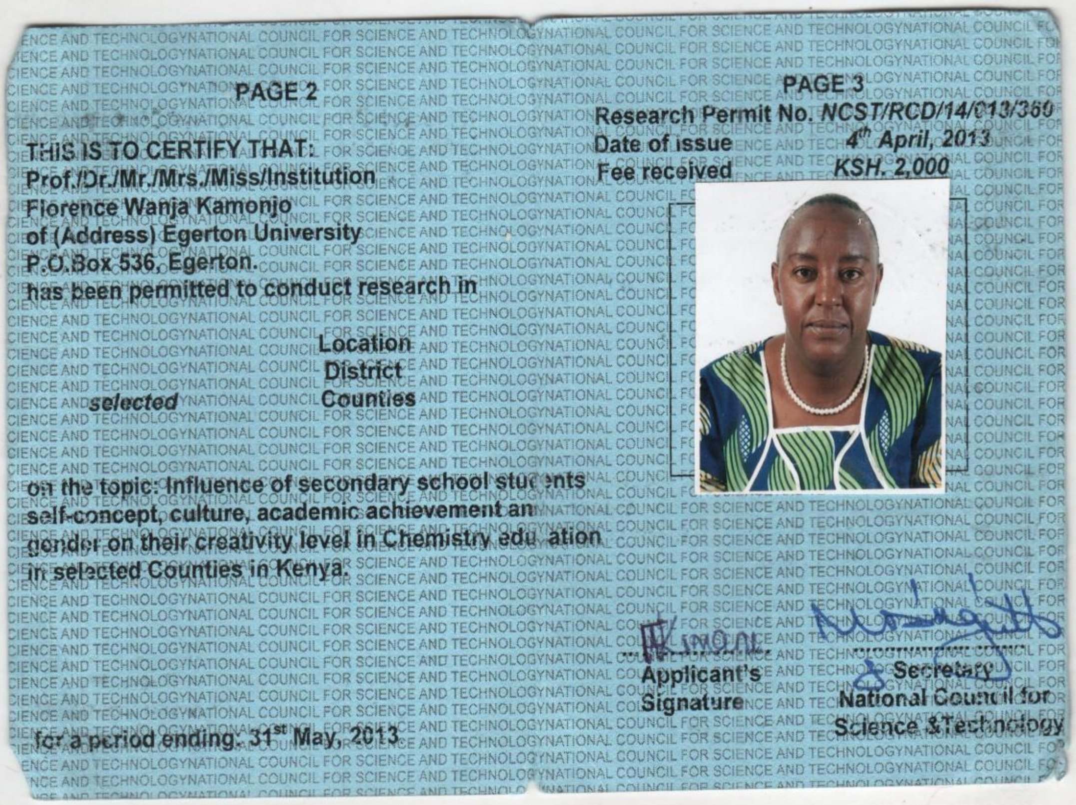
………………………………………………………………………

29. 22.2cm^3 of sodium hydroxide solution containing 4.0g per litre sodium hydroxide were required for complete neutralization of 0.1g of a dibasic acid. Calculate the relative formula mass of the dibasic acid.(Na=23, O=16, H=1) (4 marks)

……………………………………………………………………………………………………
……………………………………………………………………………………………………
………………………………………………………………………………

30. Draw a well labelled diagram showing a set-up for laboratory preparation and collection of dry hydrogen chloride gas (3 marks)

APPENDIX D: RESEARCH PERMIT



PAGE 2

THIS IS TO CERTIFY THAT:
Prof./Dr./Mr./Mrs./Miss/Institution
Florence Wanja Kamonjo
of (Address) Egerton University
P.O.Box 536, Egerton.
has been permitted to conduct research in

Location
District
selected Counties

on the topic: Influence of secondary school stu[illegible]nts self-concept, culture, academic achievement an[illegible] gender on their creativity level in Chemistry edu[illegible]ation in selected Counties in Kenya.

for a period ending: 31st May, 2013.

PAGE 3

Research Permit No. *NCST/RCD/14/013/360*
Date of issue *4th April, 2013*
Fee received *KSH. 2,000*

Applicant's Signature

Secretary
National Council for Science &Technology

APPENDIX E: RESEARCH PERMIT

REPUBLIC OF KENYA

NATIONAL COUNCIL FOR SCIENCE AND TECHNOLOGY

Telephone: 254-020-2213471, 2241349, 254-020-2673550
Mobile: 0713 788 787 , 0735 404 245
Fax: 254-020-2213215
When replying please quote
secretary@ncst.go.ke

P.O. Box 30623-00100
NAIROBI-KENYA
Website: www.ncst.go.ke

Our Ref:
NCST/RCD/14/013/360

Date:
4th April 2013

Florence Wanja Kamonjo
Egerton University
P.O.Box 536-20115
Egerton.

RE: RESEARCH AUTHORIZATION

Following your application dated ***27th March 2013*** for authority to carry out research on "***Influence of secondary school students' self-concept, culture, academic achievement and gender on their creativity level in Chemistry education in selected Counties in Kenya"*** I am pleased to inform you that you have been authorized to undertake research in **selected Counties** for a period ending **31st May 2014.**

You are advised to report to **the District Commissioners and the District Education Officers of selected Counties** before embarking on the research project.
On completion of the research, you are expected to submit **two hard copies and one soft copy in pdf** of the research report/thesis to our office.

DR. M. K. RUGUTT, PhD, HSC.
DEPUTY COUNCIL SECRETARY

Copy to:

The District Commissioners