Relationship between Secondary School Boys’ & Girls’ Chemistry Self Concept and their Scientific Creativity in Selected Counties in Kenya

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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-industrialized, middle-income country with a high quality of life for all its citizens in a clean and secure environment by the year 2030. To realize this vision, Kenya 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. Kenya secondary school Chemistry, Physics and Biology syllabi recommend the acquisition of creative skills by students. However, few studies have been carried out with regard to scientific creativity in secondary schools. The purpose of this study was to examine the relationship between learner’s self-concept and scientific creativity in chemistry education in Kenya. It also examined the influence of gender on scientific creativity. The study involved ex-post facto research with causal-comparative and correlational designs. The population of the study was all Form Three students in National Secondary Schools in Nairobi and Kiambu Counties and all Form Three students in District Secondary Schools in Muranga and Kajiado counties in Kenya. A sample of 16 schools (4 Boys’ and 4 Girls’ National schools and 4 Boys’ and 4 Girls’ District schools) was obtained for the study through stratified random sampling. Participating Form Three streams in the schools were selected through random sampling. A total of 640 students, (320 boys and 320 girls) were involved in the study. Data were collected using the Chemistry Scientific Creativity Test (CSCT) and the Students’ Self-Concept Questionnaire (SSCG). The test items were piloted in two schools; a National and a County school in Nakuru County. Data were analysed using Pearson Product Moment Correlation Coefficient and t-test. Tests of significance were done at 0.05 alpha level. The findings of this study showed that scientific creativity is positively related to learners' chemistry self-concept. The findings further indicated 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.

Keywords: Chemistry Self-Concept, Gender, Scientific Creativity.

Introduction
Chemistry is one of the three science subjects taught in Kenyan secondary schools, the other two being Biology and Physics. The chemistry syllabus emphasizes creative ability in students by stating 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 Kenya Examination Council (KNEC 2002). The other major objective of Chemistry, according to the syllabus is that the 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 emphasized.

The concept of creativity has been used frequently in various fields of study with different meanings. According to Treffinger, Young, Selby and Shepard (2001) creativity is the ability to generate ideas by digging and exploring deeper into ideas. It also involves listening to one's inner voice. It is an open exploration or search for ideas in which one generates many other ideas. This process leads to fluency flexibility and originality in individuals. Creative individuals are divergent thinkers (Guilford, 1983).

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 (Treffinger, 2002).

According to Treffinger (2001) and Loehle (1990) many characteristics associated with creativity are not innate but can 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 and develop it. In support Polya (1957) states that skillful 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 to establish whether it is influenced by learner's self-concept, and gender.

Self-concept can be defined as how people feel about themselves. 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 with 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. 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 success in school. 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.

Success in school, 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. Some theories suggest that creativity may be particularly susceptible to affective influence (Fredricks on, 2001). Thus, a person's creative ability may be affected by his or her self-concept. Hence this research aims at studying this relationship.

Inconsistent research findings have been reported on creativity. With younger students prior to grade three, Kogan (1974); 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); Warren and Luria (1972) found higher scores for girls in early adolescence on figural creativity. Likewise, Torrance (1983) reported 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, 1983). 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.

As apparent from the above studies, many examinations of gender differences in creativity have shown that girls score higher than boys’. 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.

**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 industrialized, 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 of secondary school chemistry learning in Kenya 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, 2010). However, a person’s creative ability may be related to his or her self concept. Also it may be related to the person’s gender. But these relationships are not clear so the researchers set out to shed light in this area.

**Objectives of the study**

The objectives of the study were;

i) To determine whether there is a difference between Boys' and Girls' scientific creativity in chemistry education.

ii) To determine the relationship between students’ chemistry self-concept and their scientific creativity in chemistry education amongst Form Three chemistry students.

**Hypothesis of the study**

The following null hypotheses were tested.

H₀₁: There is no statistically significant difference between Form Three boys’ and girls’ scientific creativity in chemistry learning.

H₀₂: There is no statistically significant relationship between learners’ chemistry self concept and scientific creativity in chemistry learning among Form Three students.

**Conceptual Framework**

The diagrammatic representation of the interaction of the various variables in the study is illustrated in Figure 1.
INDEPENDENT VARIABLES

LEARNERS FACTORS
- Learner’s self concept
- Gender

CREATIVITY IN CHEMISTRY EDUCATION
- Flexibility
- Recognition of relationships
- Sensitivity to the problem
- Planning for scientific investigation

SCHOOL FACTORS
- Type of school
- School environment

TEACHER FACTORS
- Teaching experience
- Teacher qualification

INTERVENING VARIABLES

Figure 1 Conceptual Framework of the study

The independent variables in this study were learner’s gender and self concept while the dependent variable was learner’s creativity.
Intervening variables in the study were controlled. Teacher experience was controlled by involving classes taught by chemistry teachers with at least 3 years teaching experience. Teacher qualification was controlled by involving classes taught by trained (Diploma or Graduate) chemistry teachers. Other intervening variables are schools factors such as; type of school and school environment. These were controlled by involving district secondary schools.

**Research Design**

The study involved ex post facto research in which the researchers 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 and Voegtle, 2006). 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 another but it enables researchers to determine the relationships or association between two or more variables.

**Target Population and Accessible Population**

The study targeted Form Three Students in National and County schools in Nairobi, Kiambu, Muranga and Kajiado counties of Kenya. National schools represent the top cream of academic ability in Kenya. Only those who 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 corners of the republic. County schools on the other hand admit average performers. Admission is 100% of its students from the district the school are situated. The accessible population from which the sample was drawn included 8 National schools (4 Boys only and 4 Girls only) from Nairobi and Kiambu Counties. Eight County schools were put of the accessible population of the study. Four County schools (2 Boys only and 2 Girls only) from Kajiado District in the Rift Valley Province and 4 county schools (2 Boys only and 2 Girls only) from Murunga County in the Central Province were involved in the study. Form Three students were involved in this study because the school administrators are always reluctant to allow the involvement of Form Four classes since they are an examination class. The Form Three classes were appropriate for the study since they had covered enough chemistry content for the purpose of this study.

**Selection of Participating Schools**

A list of all National schools in the two Counties (Nairobi and Kiambu) under study was obtained from the Ministry of Education Office. This list formed the sampling frame of the National schools. Using stratified random sampling method, Girls only and 4 Boys only schools were selected. As for County schools a list of all the county schools in the Muranga and Kajiado, was obtained from the Ministry of Education Office. These lists formed the sampling frame of the County schools. Using stratified sampling method 4 Girls only and 4 Boys only schools were selected.

**Selection of Participating Stream and sample size**

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 was through simple random sampling procedure. On this basis a sample of 672 students was obtained.

**Instrumentation**

Two instruments were used in this study. These are;

a) Chemistry Scientific Creativity Test (CSCT)
b) Students self concept Questionnaire (SSCQ)
These instruments are discussed below.

**Chemistry Scientific Creativity Test (CSCT)**
The Chemistry Scientific Creativity Test (CSCT) 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 & Adey (2002) 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; however it guided the development of CSCT. All the items in the CSCT were open-ended with each question testing different aspects of creativity. The test was aimed at assessing Form Three learners' competence in scientific creativity abilities which include:
- Recognition of relationships
- Flexibility
- Sensitivity to the problems
- Planning of investigations in chemistry.

The test was piloted with 160 Form Three students in four schools (two National and two District school) from Nakuru County with the same characteristics as the sample schools. A specialist in scientific creativity and science education moderated the CSCT items and the scoring key before piloting.

**Reliability of CSCT**
Items in CSCT yielded a range of scores. To estimate the reliability of such an instrument, Ebel and Frisble (1991) with 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.

**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 exiting 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 researchers sort 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 provinces 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 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 (Cronbach, 1951) index. 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, Wringsman and cook, 1976 cited in Githua, 2002). The reliability coefficient was 0.94. This falls within acceptable limits for teacher made tests of 0.7 (Ebel & Frisble, 1991).

### Table 1
Summary of Data Analysis

<table>
<thead>
<tr>
<th>Hypotheses</th>
<th>Independent Variable</th>
<th>Dependent Variable</th>
<th>Method of Data Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>$H_01$: There is no statistically significant difference between Boys’ and Girls’ scientific Creativity in chemistry education.</td>
<td>Gender</td>
<td>Scientific creativity in chemistry education</td>
<td>t-test</td>
</tr>
<tr>
<td>$H_03$: There is no statistically significant relationship between learner’s chemistry self concept and scientific creativity in chemistry education amongst Form Three chemistry students.</td>
<td>Learners Chemistry self concept</td>
<td>Scientific creativity in chemistry education</td>
<td>Pearson r</td>
</tr>
</tbody>
</table>

### Results and Discussion
This study sought to establish whether there is a significant difference between Form Three Boys’ and Girls’ scientific creativity in Chemistry learning. In addition, it sought to establish whether there is a significant relationship between learners chemistry self concept and scientific creativity in chemistry learning. The results are presented below.

#### Difference in Performance in Chemistry Scientific Creativity Test by Gender
To determine whether gender had an influence on scientific creativity raw scores in scientific creativity were used to calculate the mean score by gender. The results are shown in Table 2.

### Table 2
Means and Standard Deviations of the Scores Obtained by Boys and Girls in the Chemistry Scientific Creativity Test (CSCT)

<table>
<thead>
<tr>
<th>Gender</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
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Table 3
T-Test analysis of Boys’ and Girls’ mean scores in CSCT

<table>
<thead>
<tr>
<th></th>
<th>T</th>
<th>df</th>
<th>sig. (2-tailed)</th>
<th>Mean Difference</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equal variances assumed</td>
<td>1.621</td>
<td>670</td>
<td>0.071</td>
<td>1.836</td>
<td>672</td>
</tr>
<tr>
<td>Equal variances not Assumed</td>
<td>1.628</td>
<td>597.79</td>
<td>0.070</td>
<td>1.836</td>
<td>672</td>
</tr>
</tbody>
</table>

The differences is not significant at the 0.05 level.

The results in Table 3 show 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, H₀ is retained.

Discussion of Results

Results of this study show that there is no difference in scientific creativity of boys as compared to that of girls. However, Kogan (1974); Tegano and Moran (1989) found a tendency for girls to score higher than boys. But boys scored higher on originality. Coone (1969); 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 (2003) found out that in Biology, boys got higher mean scores than girls. In addition Hungi (2009) and Okere (1986) found that there was a statistically significant gender difference scientific creativity in favour of boys. They found out that in biology and physics scientific creativity was gender dependent.

Relationship between Students' Chemistry Self-Concept and Scientific Creativity in Chemistry Learning

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 results are shown in the Table 4.

Table 4
Person Product Correlation Coefficients for Learners' Scores in the Chemistry Scientific Creativity Test and Students Chemistry Self-Concept Questionnaire

<table>
<thead>
<tr>
<th>Chemistry Scientific</th>
<th>Students Chemistry</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The results of the analysis show that there is a statistically significant relationship between students chemistry self-concept and chemistry scientific creativity. This is because $r = 0.16^{**}$, $p<0.05$. This means that students with positive chemistry self-concept got high scores in chemistry creativity test compared to those with negative chemistry self concept. Therefore, $H_0$2 is rejected.

**Discussion of Results**

The results in Table 4 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 which state that creativity may be particularly susceptible to affective influence. Fredrickson (2001) stated that positive emotions such as joy and love broaden a person's available repertoire of cognition and actions, thus enhancing creativity. According to this researcher 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, 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.

**Conclusion**

Based on this study, the following conclusions are reached;

i) Scientific creativity of secondary school chemistry students is not influenced by gender

ii) Scientific creativity in chemistry learning is positively related to learners’ chemistry self-concept.

These Conclusions imply that both boys and girls scientific creativity can be developed through teaching of Chemistry. In addition, scientific creativity can be enhanced by addressing learners’ self-concept.

**Recommendations**

The findings of this study show that both boys and girls have the same level of scientific creativity. Therefore, chemistry teachers in boys’ and girls’ schools should use similar methods of teaching. In addition a learner’s self-concept is related to scientific creativity. If secondary school teachers use methods of teaching that enhance a learner’s self-concept, then their creativity may be improved. Such methods may involve co-operative and experiential learning approaches.
References