Influence of Gender and Knowledge on Secondary School Students' Scientific Creativity Skills in Nakuru District, Kenya

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The purpose of this study was to investigate the influence of gender and knowledge on scientific creativity among form three biology students (third year in secondary school cycle) in Nakuru district in Kenya. The cross- sectional survey research was employed. The population of the study comprised all form three biology students in public secondary schools in Nakuru district. A sample of eight schools with a total of 363 students was selected from the population using stratified sampling technique. Two instruments, namely, Biology Achievement Test (BAT) and Biology Scientific Creativity Test (BSCT) were used to collect data. The psychological definitions of creativity tested are sensitivity, recognition, flexibility and planning. The mapping of these psychological definitions of creativity onto scientific meanings is explained using the model that guided construction of items in BSCT. Data analysis was done using quantitative methods. The statistics used were Pearson correlation coefficient(r), chi-square, t-test and ANOVA, at α=0.05 level of significance. The findings of this study indicate that the form three biology students who participated in the study had a low level of scientific creativity. Secondly, the level of scientific creativity is knowledge and gender dependent. The findings may help teachers and other stake holders in education in inculcating creativity skills amongst science students.

Key words: Influence, Gender, Knowledge, Scientific creativity

Treffinger (2002) argues that much of what we know today we did not know four decades ago, and in the not-very-distant future much of what we think we know now, will be absolutely irrelevant. He further argues that the "shelf life" of knowledge in this time of constant change and how long knowledge lasts before it is overcome by events or replaced by new, better or different knowledge is getting shorter and shorter. Therefore, students will need another kind of information and tools, "Knowing how" to access, organise, modify, use and construct information. What Treffinger has suggested are the attributes and skills that should be acquired by students if they are to be creative in the scientific discipline. Loehle (1990) argues that, those areas of science such as biology, medicine and theoretical physics need more creativity because the phenomena involved in those subjects are complex. The term creativity has been used and given different meanings in different fields. According to the heritage dictionary, originality and imagination characterize creativity. Some of the important instances of creativity include discoveries of knowledge in science and medicine, invention of new technology, composing beautiful music or analyzing situations in a new way (Standler, 1998). Crawford (1954) is credited with starting a training course to increase creativity among professionals by use of attribute listing. This involved putting down certain attributes of a product and the modifications that could be done to each attribute to improve it. Treffinger, Isaksen and Dorval (2000) emphasized the importance of a balance between creative and critical thinking during effective problem solving and decision making. They define creative thinking as the encountering of gap, paradoxes, opportunities, challengers, or concerns, and then searching for meaningful new connections by generating many possibilities, varied possibilities, unusual or original and details to expand or enrich the possibilities. They say that, critical thinking involves examining possibilities carefully, fairly, and constructively, and then focusing thoughts and actions by

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organizing and analyzing the possibilities. It can be noted from this definition that creative thinking is in dissociable from critical thinking. Ennis (1989) says that creativity is important in science because science is changing rapidly with many discoveries, hence- spoon feeding in schools cannot help learners develop creative skills.

Vernon (1982) asked "Why so far women have not shown outstanding creativity in any field? Is it that they are not creative or they are not provided with learning opportunities that enhance the acquisition of scientific creativity?" Quantitative review of gender differences in school science achievement reveals significant gender differences in science achievement (Steinkamp & Maehr 1983; 1984). A study by Otieno-Alego (1991) on competence of junior secondary school pupils on the science process skills of observation, prediction, generalization and control of variables, showed that boys performed significantly better than girls. On open-mindedness, boys were relatively more competent than girls. However both boys and girls had low levels of open-mindedness. Most studies done on gender conclude that boys generally perform better than girls especially in practical in science (Eshiwani, 1986). This was attributed to lack of confidence in handling of equipment's, tools and materials. However, Mondoh (1986) found that there was no significant difference between boys and girls in performance of some mathematical concepts.

Okere (1986) showed that both physics knowledge and context of application contribute to creativity. It is therefore important to find out whether these findings can be generalized to other science subjects like biology, especially the effect of biology knowledge on scientific creativity. Okere also identified aspects of scientific creativity that can be taught and assessed in secondary schools. These include sensitivity, flexibility, recognition of relationships and planning for investigation. Sensitivity refers to the ability to rephrase general statements so that they can be checked scientifically, criticize experimental procedures and identify sources of errors in an experiment. Flexibility refers to the ability to provide many correct responses to a problem. Recognition of relationships is the ability to formulate hypotheses about relationships among variables. Planning is the ability to design experiments, state dependent, independent and control variables.

According to Burt (1962) education cannot create creativity but can encourage and develop it. This is further supported by Treffinger et al. (2001) and Loehle (1990) who argue that many characteristics associated with creativity are not innate but can be taught and nurtured. They also argue that creative behavior is influenced by motivational as well as situational factors. Parnes (1963) talks of the role of educational experience in developing creative scientific talents. He argues that creative activity represents to some extent many learned skills and hence learning can extend the skills within limitations. Polya (1957) also supports this by saying that ability to discover and the ability to invent can be enhanced by skillful teaching.

Various scholars have investigated the relationship between creativity and intelligence. Getzel's and Jackson (1962) investigated it using two groups from a population. In one group the pupils had high IQ but low creativity scores while the other group had pupils with low I.Q but high creativity scores. They then administered school achievement tests and found no significant difference in the scores of the two groups. Barron (1969), Mackinnon (1968) and Roe (1965) have all mentioned that there is a threshold effect for IQ, such that above a certain level required for the mastery of a field, IQ is not correlated to creativity. Mackinnon (1968) argued that "a mature scientist with an adult IQ of 130 is as likely to win a Nobel Prize as one whose I.Q is 180". It is therefore clear that a creative individual is intelligent to a reasonable extent. This is required for one to be able to organize his/her ideas to make any productive contribution to his/her field of study. Cropley (1966) using an unselected group of children did the same research. He used two tests, intelligence and creativity tests which he factor analyzed. From his findings he concluded, "It is unacceptable to think of creativity as a separate basic intellectual mode". Lovel and Shields (1967) came to the same conclusion as Cropley concluding that an able pupil is creative to different degrees according to the task set before him. Freeman, Butcher and Christie (1971) summarizes the relationship between intelligence and creativity by saying that creativity overlaps very considerably with intelligence as assessed by conventional tests.

One of the main objectives of education in Kenya is the development of creative and innovative minds amongst learners (Republic of Kenya, 1999). This is because accelerated industrial development can only take place if future manpower is trained to think creatively. Kenya is a country that hopes to be industrialised by the year 2030 (Republic of Kenya, 1992; 1997; 2007) and hence the need to develop the creative skill amongst our students.

Purpose of the Study

The purpose of this study was to investigate the effects of gender and knowledge on the level of scientific creativity skills in biology amongst form three students in Nakuru district in Kenya.

Objectives

The following objectives guided the study:

(i) To determine the level of scientific creativity skills amongst form three biology students.

(ii) To investigate if there is a significant relationship between the level of scientific creativity skills in biology and biology knowledge.

(iii) To investigate if the level of scientific creativity skills in biology is gender dependent.

Methodology

The cross-sectional survey research design was used in this study. The target population was Form three biology students in public secondary schools in Nakuru district. The schools in Nakuru district were categorized as mixed schools, girls' schools and boys' schools. The schools in each category formed a sampling frame. Using Stratified random sampling method, 2 schools from each category of boys' and girls' and 4 from mixed, were selected. This ensured fair distribution of the different schools by gender. The selection of the form three classes that participated in study was done by simple random sampling. This is because the schools had more than one stream in each class. The total number of students in form three in all the 8 schools was 363, 87 were from boys' schools, 134 were from girls' schools and 142 were from mixed schools. Two instruments namely, biology achievement test (BAT) and biology scientific creativity test (BSCT) were used. The two tests were constructed by the researchers and validated by three experts in creativity in science education from Egerton University.

Biology Achievement Test (BAT. The BAT was aimed at assessing learners' knowledge of biology content. The test items were drawn from the same topics as those of BSCT. The BAT had 24 items that were open-ended. The test was pilot tested in two secondary school schools in Nakuru district. The test had a reliability coefficient of 0.72 estimated by Cronbachs coefficient alpha.

Biology Scientific Creativity Test (BSCT). The (BSCT) was used to assess students' level of scientific creativity skills in biology. The items were drawn from form one to form three biology content covering the same content as the BAT. The scientific creativity skills covered in the test were reformulating general statements, devising and describing investigations and generating hypotheses. The mapping of the psychological definitions of creativity, namely, sensitivity to problems, recognition of relationships, flexibility in reasoning and planning onto the scientific meanings is shown in Okere's (1986) model figure1. The reliability coefficient estimated by Cronbach's α was 0.60.

Psychological Meanings of Creativity

Okere (1986) summarised the psychological meanings of creativity under the following sub- headings:

(a) Sensitivity to problems

Torrance (1962) defined creativity as the ability to be aware of problems, think of possible solutions to the problems and test the practicability of the solutions. Bartlet (1958) and Parnes (1963) pointed out that a competent research scientist is one who is capable of identifying problem sites that require concentration and defining the problems appropriately for creative attack. Torrance (1988) defined creativity as the process of sensing difficulties, problems, gaps in information, missing elements, making guesses and formulating hypotheses. In science education, this ability can be assessed by problems that require students to identify statement that cannot be checked scientifically, criticize given experimental procedures, spot fallacious arguments or suggest possible sources of errors in an experiment (Okere, 1986).

(b) Recognition of Relationships

According to Rogers (1954) a creative individual should recognise relationships among concepts and retrieve earlier experiences whenever he/she encounters a new situation. In science education this description could apply to a student who can recognise relationships between everyday observations/phenomena and the concepts acquired from science lessons (Okere, 1986)

(c) Flexibility in reasoning

(d) Guilford (1967) hypothesised that creative thinkers are flexible thinkers. They readily desert old ways of thinking and strike out in new directions. In science education, this ability can be assessed by problems that require students to design for an investigation and then suggesting various approaches that can be used to evaluate the dependent variable or a problem requiring generating hypotheses using different topics in a given subject (Okere, 1986).

(e) Planning for Investigation

According to Parnes (1963) and Hudson (1967) this ability can be displayed in problems that require students to propose and devise experiments to test a given hypothesis.

Scientific Meanings of Creativity Tested

Design of Investigations

(a) Reformulating General Statements.

In this case a student should be able to rephrase statements in such a way that they could be checked. This means that a student should first be able to identify the inadequacy of a given statement and also to suggest how it can be rephrased such that it is testable.

(b) Criticizing Experimental Procedures.

In this case the student should be able to identify what is wrong with an experimental procedure. This means that the student should be able to identify the variables that need to be controlled to make the results of the investigations fair.

(c) Devising and Describing of Investigations

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

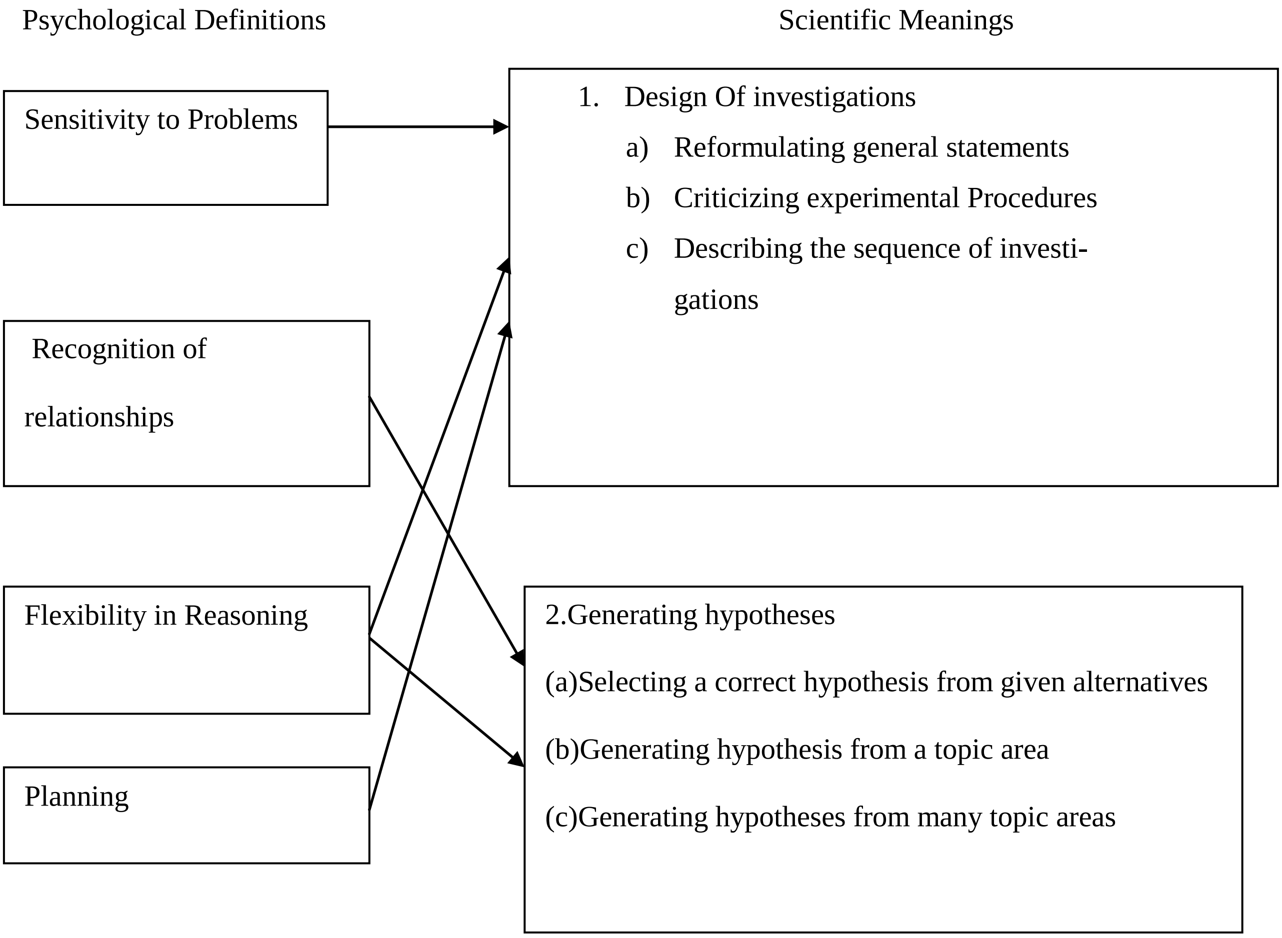

Figure 1.The Mapping of Psychological Definitions of Creativity on to Scientific Meanings (Okere ,1986)

Generating Hypothesis

(a) Generating a hypothesis from a particular topic area

In this case a student is asked to suggest causes of given biological phenomena or described observations. This will require the student to generate a hypothesis based on a particular topic and give reasons for deciding on the particular hypothesis.

(b) Generating hypotheses from many topic areas

Here a student is required to generate many possible hypotheses from various biology topics when explaining causes of biological phenomena or observations.

The model shows the mapping of psychological definitions of creativity onto the scientific meanings. The model guided the development of the items in the BSCT test. The construct validity of the model had been checked by computing the Pearson product moment correlation coefficient between score on items in physics subject and scores on Torrance Test of Creative Thinking, Verbal Version. The correlation between the two tests was equal to 0.53. The physics items were not suitable for the present study because creativity in science is knowledge dependent. All the items used in this study were open-ended. Each item tested a different skill of scientific creativity. Cronbach's coefficient alpha for BSCT was equal to 0.60. The two tests were piloted with 80 form three biology students in two schools in Nakuru district. The items were found adequate for the investigation.

Sample items on each aspect of the psychological definitions of scientific creativity
Item on sensitivity
The following statement is not testable scientifically.
One morning, a mother told her daughter "tea is better for you than coffee."
Rephrase the statement in such a way that it is testable.
Correctly rephrased statement was scored for 1 mark

Item on recognition
Walking along a footpath, Peter noticed that there was a morning glory plant growing on trees. None of the trees had the morning glory plant growing on the side nearest to the footpath. Explain why the morning plant might grow only on some sides of the trees.
A correct hypothesis generated was scored for 2 marks.

Item on flexibility
Brian asked his teacher "why is it that grasshoppers attract their mates by sound whereas peacocks attract their mates using colour?
Suggest four possible reasons why grasshoppers use sound rather than colour to attract their mates.
A total of 4 marks were scored for this item (1 mark for each correct hypothesis.

Item on planning for investigations
A farmer had two types of soils, clay and sandy soils. He wanted to find out which of the two soils is best for planting maize. Describe how he would do this. This item had a total score of 10 marks.
There are a total of 8 control variables, each was awarded one mark. There are two ways of judging which type of soil is the best planting maize (total of 2 marks).

Results

Relationship between Level of Scientific Creativity skills in Biology and Knowledge

The relationship between scientific creativity skills in biology and achievement was investigated by Person product moment correlation coefficient. The results are shown in Table 1.

Table 1 Pearson Product Moment Correlation Coefficients for Learners' Scores on BSCT and BAT

	Mean (%)	Std deviation	Learners score on the BAT	Learners score on the BSCT
Learners score on the BAT	46.6418	13.2821	1.00	0.577**
Learners score on the BSCT	26.6281	11.5446	0.577**	1.00

** Correlation is significant at the 0.01 level

The above results show that the mean score on the biology scientific creativity test was 26.628 % with a standard deviation of 11.545. The mean score on the biology achievement test was 46.642 % with a standard deviation of 13.282. The Pearson correlation coefficient between the BSCT and the BAT was equal to 0.577. This was significant at the 0.01 level. This implies that a good mastery of the biology content is essential for effective development of scientific creativity skills in biology. Multiple correlation matrix showing intercorrelations of the four aspects of definitions of scientific creativity, the total creativity score and achievement score is shown in Table 2

Table 2. Pearson Product Moment Correlation Coefficients for Learners Scores on Flexibility, Recognition of Relationship, Sensitivity, Planning, BAT Test and Overall BSCT Test

	Flexibility	Recognition of relationship	Sensitivity	Planning	%BAT score	% BSCT score
Flexibility						
Recognition of relationship	.727**					
Sensitivity	.231**	.350**				
Planning	.283**	.381**	.617**			
% BAT score	.466**	.4866**	.399**	.390**		
% BSCT score	.743**	.839**	.685**	.749**	.571**	

**Correlation was significant at 0.01level

The results in table 2 indicate that flexibility, recognition of relationship, sensitivity, planning, and BSCT scores and biology achievement test scores are all positively correlated and significant. However some correlations are significant but quite low. For example, the correlations between sensitivity and flexibility, sensitivity and recognition of relationship, planning and flexibility, planning and recognition of relationship are low but significant. The low correlations between the various aspects of creativity imply that they measure different aspects of scientific creativity. However the correlations between recognition of relationship and flexibility, and between sensitivity and planning were significant and high. This gives an indication that perhaps they measure the same aspect of creativity.

Relationship between the Level of BSCT and Gender

The learner's raw scores on the biology scientific creativity test were expressed in percentages. Those who scored 40% and above, were categorised as having high scientific creativity skill while, those who scored less than 40% were categorised as having low scientific creativity skill.Chi-square for the categorised scores and gender was computed using SPSS version 11.5 programme. The results are shown in Table 3.

Table 3. Chi-square for Learners Categorised Scores on BSCT by Gender

	Boys	**Girls**	**TOTAL**
High	39	12	51
Low	137	175	312
TOTAL	176	187	363

The chi-square value was 18.606 with one degree of freedom. The test of significance was at 0.05. The critical Chi-square value is 3.84. The calculated value is much greater than the critical value and hence significant at 0.05 level. The null hypothesis was therefore rejected. This shows that scientific creativity in biology is gender dependent. Tables 4 and 5 show the performance on various aspects of scientific creativity by gender.

Table 4. Learners Categorised by Gender for each Aspect of Scientific Creativity in Biology

	Boys		Girls		Total	
Aspects of scientific creativity	High	Low	High	Low	High	Low
Flexibility	90	86	53	134	143	220
Recognition of relationship	94	82	56	131	150	213
Sensitivity	61	115	34	153	95	208
Planning	6	170	2	185	8	355

It can be noted from table 4 that more boys had a high level of scientific creativity in biology than girls. The chi-square value was computed to find out if there was a statistical significant relationship between gender and level of scientific creativity in each aspect of scientific creativity. The results are given in table 5.

Table 5. Chi-square Value between each Aspect of Scientific Creativity Skill and Gender

Aspects of scientific creativity	Value	Df	Assymp.sig	Exact sig
Flexibility	19.731	1	.000	.000
Recognition of relationship	20.585	1	.000	.000
Sensitivity	12.740	1	.000	.000
Planning	2.303	1	.129	.164

Chi-square critical value=3.84 *Significant at 0.05 level

Table 5 shows that the chi-square values for the relationship between flexibility, recognition of relationships and sensitivity and gender were all significant. This indicates that there was a significant relationship between all aspects of scientific creativity and gender except planning. In order to identify which group performed significantly better than the other, raw scores on each aspect of scientific creativity was used to compute their means. The results are shown in tables 6 and7

Table 6. The Means by Gender and Standard Deviations on all Aspects of Scientific Creativity and Final Scientific Creativity Test

Aspect of scientific creativity	**Gender**	**Mean**	**Std deviation**
Flexibility	Boys	4.3807	1.9176
	Girls	3.5455	1.7202
Recognition of relationship	Boys	5.9801	2.2762
	Girls	4.6791	2.1399
Sensitivity	Boys	2.7614	1.6106
	Girls	1.9599	1.4700
Planning	Boys	2.6506	2.3528
	Girls	1.7968	1.7075
Scientific creativity	Boys	30.4091	11.6306
	Girls	23.0695	10.2889

From Table 6 it is evident that the mean for boys is higher than the mean for girls in flexibility, recognition of relationship, sensitivity, and planning and overall scientific creativity test. Further analysis was done using independent sample t-test, to find out if the mean differences were significant. The table 7 shows the t-test results.

Table 7. T-test Results between Gender and All Aspects of Scientific Creativity in Biology

Aspects of scientific creativity	t-value	Df	Sig(2-tailed)
Recognition of relationship	5.613	361	.000
Flexibility	4.373	361	.000
Sensitivity	4.956	361	.000
Planning	3.974	361	.000
Overall scientific creativity	6.377	361	.000

The above table shows that the mean differences between boys and girls in all aspects of scientific creativity in biology and the overall scientific creativity in biology were significant in favour of the boys.

Discussion

The findings in table 1 indicate that the correlation between the learners score on the biology scientific creativity test and the biology achievement test was positive and statistically significant. This suggests that a good mastery of the biology content is essential for effective learning of scientific creativity in biology. These findings agree with Okere's finding (1986) which showed that physics knowledge is a necessary but not sufficient condition for creativity in physics education. Weiner (2000) also argues that knowledge of what has been learned, generally, functions as a prerequisite to creating anything that has not been. Dunbar (1999) supports this when he points out that knowledge is pre-requisite for creative production in science.

Each aspect of scientific creativity correlates highly with the overall biology scientific creativity test (Table 2). This indicates that they measure the same construct. The correlation between biology achievement test with sensitivity and planning was lower than with flexibility and recognition of relationship. Sensitivity and planning were measured in the design of investigations, while flexibility and recognition of relationship were measured in the generation of hypotheses. The findings indicate that biology knowledge may be contributing to the performance in generation of hypothesis and not in the design of investigations. This suggests that knowledge in biology is not a sufficient condition for one to develop the skill for design of investigations. This seems to further suggest that even those who do not perform well in the biology achievement test can learn the skill of design of investigations. These findings are in agreement with Okere (1988) where he found that the level of physics knowledge was contributing to performance on generation of hypothesis and not to design of scientific investigations. He also found that planning had a high correlation with Torrance Test of Creative Thinking Verbal Version, but not with physics knowledge test. This seems to suggest that knowledge could be a prerequisite for planning but not sufficient condition for one to succeed in planning for scientific investigations. The above findings agree with Okere's (1986) findings. However he found sensitivity to have a low correlation with planning unlike in this research where the two were highly correlated.

The chi-square results revealed that the level of scientific creativity is gender dependent. Aspects of scientific creativity i.e., flexibility, recognition of relations, sensitivity and planning are all gender dependent (table 5). From the mean scores (tables 6 and 7) boys performed better in all aspects i.e. flexibility, recognition of relationship, sensitivity, and planning and overall scientific creativity. The difference could be related to knowledge level in biology. Boys had higher mean scores in both creativity and achievement as shown in table 8. This is in agreement with Taasooboshirazi and Carr (2008) study which indicated that females scored lower on standardized test in sciences and mathematics.

Table 8. Comparison of means scores of both BSCT and BAT by gender

	Gender	N	Mean	Std deviation
BSCT	Boys	176	30.4091	11.6306
	Girls	187	23.0695	10.2889
BAT	Boys	168	48.8929	13.4044
	Girls	181	44.5525	12.8549

BAT was significantly correlated with BSCT. Therefore the low level of scientific creativity achieved by girls can be attributed to their low level of biology knowledge. Other researches done on gender difference in science achievement show that boys perform better than girls. For example Otieno (1991) did a study on competence of junior secondary school pupils in some science process skills and found that boys did much better as compared to the girls. Steinkamp and Maehr (1983; 1984) argue that quantitative review of gender differences in school science achievement all reveals significant gender differences in science achievement. However according to Christine (2005); Baer and Kaufman (2008), there is no gender difference in scientific creativity. Halpern, Benbow, Geary, Gur, Hyde and Gernsbacher (2007), argue that females excel in verbal abilities which are required to communicate effectively and comprehend abstract ideas. This indicates that girls can perform as well as boys in scientific creativity. However more research needs to be carried out in order to find out why girls are not excelling as the boys yet their innate traits favour creativity.

One of the reasons given on the difference in level of scientific creativity and creativity in general between boys and girls is the association of some traits with masculinity and femininity i.e. cultural block. The mental activities associated with creativity, intuition qualitative judgement, pleasure are associated with masculinity trait (Adams 2001) However more studies need to be done on the kind of blocks hindering females from being as creative as males.

Conclusion

The first objective of the study was to determine the level of scientific creativity skills in biology education amongst form three students. Results showed that the level of scientific creativity skills of biology students was low. It was also noted that boys scored significantly higher than girls on all aspects of scientific creativity skills. These findings are in agreement with earlier findings (Okere, 1991) and Okere, Illa and Changeiywo (2010). The second objective was to investigate the relationship between scientific creativity skills in biology and biology knowledge. The relationship between the overall level of scientific creativity skills in biology and biology knowledge was statistically significant. However the correlation coefficients between some of the scientific creativity skills and biology knowledge were very low. This implies that knowledge is a necessary but not sufficient condition for creativity. Objective three investigated the relationship between the level of scientific creativity skills in biology and gender. The relationship between the two variables was statistically significant at the 0.05 level. All the other aspects of scientific creativity skills were also gender dependent.

Implications

The findings of this study have shown that secondary school biology students have a low level of scientific creativity skills. This implies that biology teachers are probably not providing learning opportunities that can enhance the acquisition of scientific creativity skills. For example, it has been shown that concept mapping teaching strategy improves students' scientific creativity in physics (Okere et al., 2010). Adams (2001) argues that teachers do not encourage the questioning attitude among learners and yet this is one of the activities that can be used to overcome conceptual blocks to creativity in science education. Amabile (1983) quotes Albert Einstein who said, "It is nothing short of a miracle that the modern methods of instruction have not yet entirely strangled the holy curiosity of inquiry, it is a very grave mistake to think that enjoyment of seeing and searching can be promoted by means of coercion and a sense of duty." This is supported by Weiner (2000) who explains that teachers tend to lead students step by step towards an established fixed realm called knowledge in which the teacher appears as the possessor of the object of knowledge. This results in exploration and creativity being minimised.

Recommendations

- Teachers should use appropriate teaching strategies that can enhance acquisition of scientific creativity skills.
- In-service workshops should be arranged for teachers to make them aware of the low level of level of scientific creativity skills amongst students.
- Amabile (1983) conducted research in educational institutions and found that rewards and punishment hinders creativity. He explained that the acknowledgement of one "right answer" reduces the room to imagine be innovative. Thus if Kenya is to achieve the

objective of being industrialised by 2030(Republic of Kenya, 2007) then the science school curriculum should have activities enhance scientific creativity skills.

- Gender was significantly correlated with the level of scientific creativity at the 0.05 level. Boys were competent in all aspects of scientific creativity than girls. But according to Werner (2000) and Adams (2001), emotion, openness and sensitivity which are associated with creativity are ones own culture traditional stereotypes as "female". Therefore, if girls are encouraged and helped to eliminate cultural blocks that limit their opportunities for creative expression, they can produce greater creative works in science. The implication is that teachers should encourage girls to have a questioning attitude during science lessons.

Suggestions for Further Research

The findings of this study suggest that knowledge in biology does affect level of scientific creativity in biology. This is in agreement with a study carried out by Okere (1986). This study further suggests that gender does affect the level of scientific creativity. However, further research is required to corroborate these findings, and more especially in the following areas of concern:

- Investigations with a large sample involving more schools from different regions of Kenya.
- Studies aimed at finding out more obstacles to scientific creativity.
- Studies aimed at evaluating effects of schools categories (mixed or sing sex schools) on level of scientific creativity
- Investigating influence of culture on scientific creativity
- Investigate teachers perceptions of scientific creativity.

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