

Effects of practical investigation on scientific creativity amongst secondary schools biology students in Kericho district, Kenya.

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Abstract
Changes and developments in the 21st century demand for school leavers who possess creative abilities valuable for personal, social, technological and economic development. . Many science curriculum documents assert that engaging in practical work in science can enhance scientific creativity in students. However, the laid down procedures in Kenyan secondary school biology practical work seem to hinder the development of scientific creative abilities since they do not allow students to design their investigations. This study has been conducted to examine the effect of Practical Investigation laboratory approach on scientific creativity amongst form three biology students in Kericho district. Solomon-four Non-equivalent control group design was used in the study. The population of the study consisted of all form three students in the county secondary schools in Kericho district. A sample from four schools with a total of 180 form three students was selected from the population using purposive random sampling. Two schools were randomly assigned to experimental groups while the other two into the control groups. Biology Creativity Test (BCT) and Scientific Creativity Test in Biology (SCTB) instruments were developed and validated to ascertain their efficacy in the subject area under study. The BCT was used during the pretest and consisted of 8 items designed in an open ended nature. The SCTB was used during posttest and consisted of 15 items also designed in an open ended nature. The items in the two tests were derived from the topics of nutrition, transport and ecology. Four null hypotheses were generated and tested for this study. Data obtained were analyzed using t-test and ANOVA. The results showed that there was a significant difference in students' scientific creativity when Practical Investigation laboratory approach was used as compared to conventional laboratory approach. The study concluded that Practical Investigation laboratory approach could be used to enhance scientific creativity in biology among secondary school students.
Keywords: Scientific creativity, Practical Investigation, Creative abilities, Biology, Form three

1. Introduction

The teaching and learning of science has several purposes. However the major purposes for science instruction are to enable students to acquire scientific knowledge, to develop positive attitude towards science and to acquire mental and manipulative skills (Maaundu, et.al 2005). In addition, in promoting the advancement of science through biology, the teaching and learning of this subject prepares students to think critically and develop positive attitudes towards science that enable them to provide answers to problems in terms of cause and effect rather than non-scientific explanations based on whims or superstition. On the other hand the learning of biology as well as other science subjects enables learners to acquire cognitive and manipulative skills useful in positive contribution to the society.

The Kenyan secondary school science curriculum objectives lay emphasis on the development of scientific creative abilities amongst learners (ROK, 1999). This is because industrial development can only take place if future manpower is trained to think creatively. Kenya is a country that hopes to be industrialized by the year 2030, thus the need to develop the creative skill amongst our students. In order for all members of a society to fully participate in nation building knowledge of science is essential (Keraro 2002). The learners who have cleared forth form are expected to have necessary practical knowledge and skills that they can utilize in life. One of the significance of learning biology is to develop scientific skills such as observing, identifying, analyzing and evaluating (KLB, 2011). These skills are aspects of scientific creativity which are essential during biology practical lesson.

Hu and Adey (2002) explained that there is a need for scientific creativity in secondary school science education. Firstly, 'doing science' is far more than either mastering the existing body of knowledge or following set procedures. It involves going beyond existing knowledge and techniques of creating new understanding in science. Secondly, solving problems in science requires a student to explore his/her repertoire, to imagine a variety of routes to a solution and frequently to create novel techniques for a solution. Thus scientific creativity is worthy of attention in science education so as to produce students who will either be scientists or who understand the way scientists work as part of their general understanding of the society. If scientific creativity is to become important element in science education at secondary school level then it becomes useful to develop strategies or intervention programs of enhancing it.

Science educators have recognized the importance of creativity in science education and have proposed different methods and techniques which can improve scientific creativity. Most studies have generally used cognitive aspects to determine scientific creativity of students. Cheng (2004) carried out a study on developing physics learning activities to foster scientific creativity in Hong Kong and found that using Open-Inquiry Approach can foster science student's creative abilities. Other approaches that have been established to elicit creativity among students include Creative Problem Solving (CPS) model by Isaksen et.al (2000) and the Problem-Based Learning method by Gallagher (1997). Studies on scientific creativity in science education conducted in Kenya in the recent past indicate low levels of scientific creative abilities amongst the learners (Okere, 1991, Ndeke, 2003, Okere & Ndeke, 2013). Nevertheless, Bahr et al (2006) remarked that one's level of creative functioning can be enhanced. However, Byrne (2005) pointed out that it is not known to what extent an individual's ability to create can be enhanced. Some studies done in Kenya have indicated that some appropriate instructional strategies when used enhance scientific creativity among students. A study done by Abuto (2005) to investigate the effect of Concept Mapping teaching strategy on scientific creativity indicated a significant effect on performance in scientific creative abilities by high school physic students. This study aimed at determining whether the incorporation of Practical Investigation in laboratory activities would enhance scientific creativity amongst secondary school biology students in Kericho district, Kenya.

2. Research hypotheses

The following research hypotheses were generated and tested for this study:

i. There is no significant difference on students' flexibility in reasoning between the students subjected to Practical Investigation and those not exposed to it.
ii. There is no significant difference on students' ability to be sensitive to sources of errors in an experiment and control variables between the students subjected to Practical Investigation and those not exposed to it.
iii. There is no significant difference on students' ability to plan for scientific investigation between the students subjected to Practical Investigation and those not exposed to it.
iv. There is no significant difference on students' ability to recognize relationship between general observations and scientific concepts between the students subjected to Practical Investigation and those not subjected to it.

2.1 Creativity

Creativity is a complex and diverse construct. It is hard to define because creativity is found in every domain of human activity (Clegg, 2008). According to Getzel and Jackson (1962) creativity is the ability to produce multiple, unique and elaborate solutions to problems that can be solved in more than one way. This is supported by Guilford's theory of divergent thinking which views creativity as the process of looking for ideas or solutions to problems. Isaksen .et. al (2000) defined creativity with an emphasis on the importance of balance between creative and critical thinking during effective problem solving and decision-making. They looked at creativity as the ability to generate ideas and as an open exploration or search for ideas in which one generates many ideas (fluency) and unusual or novel ideas (originality).

Boden (1998) defined creativity as a person's ability to come up with new ideas that are surprising yet intelligible and also valuable in some way. According to him, those programs that encourage idea-generation such as, brainstorming, mind mapping, check listing, investigation and creative dramatics are likely to enhance scientific creativity amongst learners. The human being is creative in a specific field (Liang, 2002). For instance while an individual is creative in chemistry he or she may not be creative in painting. Therefore it is generally necessary to distinguish scientific creativity from creativity.

2.2 Scientific creativity

The concept of creativity is very broad hence the focus of this research has been narrowed to scientific creativity. Laius et al (2008) defined scientific creativity as the teaching and learning processes based on recognizing problems and discrepancies in accepted content, looking at things in different ways, making unexpected links among apparently discrepant elements of information and developing one's own solutions to scientific problems and similar processes, rather than simply memorizing prescribed content. On the other hand Hu and Adey (2002) explain that scientific creativity is a kind of intellectual ability that depends on scientific knowledge and skills. They argued that scientific creativity is different from other creativity since it is concerned with creative science experiments, creative scientific problem finding and solving, and creative science activity. While according to (Heller, 2007) he defined scientific creativity as an individual and social capacity for solving complex scientific and technical problems in an innovative and productive way. That it is a kind of ability that depends on scientific knowledge and skills. It should be a combination of static structure and developmental structure in the sense that an adolescent and a mature scientist have the same basic mental structure of scientific creativity but that of the later is more developed. Dass (2004) pointed out that scientific creativity can be considered to help achieve new and original steps in performing the targets of science. He defined scientific creativity as comprehending new ideas and concepts added to scientific knowledge, formulating new theories in science, finding new experiments presenting the natural laws, recognizing new regulatory properties of scientific research, and giving the scientific activity plans and projects originality.

In this study, scientific creativity has been taken to mean an innate ability which is latent in all human beings in varying degrees and that every person has the capacity to be creative when provided with appropriate experiences and opportunities. This is because scientific creativity has been found to be an educable skill rather than a comprehension endowment (Dass 2004).

2.3 Measures of Scientific Creativity in relation to Science Education

Torrance (1990) considered fluency, flexibility, originality and elaboration as central features of creativity. Fluency means the number of relevant responses or ideas produced, flexibility is the ability to 'change tack', and not to be bound by an established approach after that approach is found no longer to work efficiently. Originality is interpreted statistically as an answer which is rare or which occurs only occasionally in a given population. Elaboration refers to the ability of a respondent to explain the responses. These four levels are essential for measurement of scientific creativity.

Hu and Adey (2002) pointed out that fluency, flexibility and originality form one dimension of a model which can be used to describe the characteristics of a creative person. According to them, a creative individual is able to give variety of relevant responses to solve a given problem (fluency), able to discontinue an existing pattern of thought and shift to new patterns (flexibility), and able to get away from the obvious by making big mental leap and producing novel but relevant ideas(originality). Guilford (1950) pointed out that the intellectual operation for these abilities are divergent and that can be applied to all content areas. Okere (1986) classified cognitive psychologist's definitions of creativity that seem to bear some relevance to science education into four categories:

i. Sensitivity to scientific problems
ii. Flexibility in reasoning
iii. Recognition of relationships between general observation an scientific concepts
iv. Planning of scientific investigation.

Sensitivity to scientific problems involves a student reformulating a general statement so as to make it scientifically testable, siting sources of errors and suggesting the control variables in an experiment. Lubart (1994) observed that problem solving can lead to creativity because if a problem exists then there is the possibility of creative solution. Okere (1996) set a problem named 'Coils' which required the students to suggest reasons why the given experimental procedure was not fair. His findings indicated that pupils who got correct criticisms on the procedure and identified the dependent and independent variable were creative.

Flexibility in reasoning refers to the categories of responses or approaches given to solve a problem by student. Jeffery (2005) pointed out that creative ideas are generated when one discards preconceived assumptions and attempts a new approach or method that might seem to others unthinkable.

Recognition involves a student generating hypotheses regarding the causes of given phenomena or observations. . Rogers (1954) and Bruner (1957) suggest that a creative individual should be able to recognize relationships among concepts and retrieve earlier experiences whenever he/she encounters a new situation. Okere (1986) in his findings of a 'Porous pot' experiment showed that a creative student recognized the relationship between the porous pot making water cold and the physics concept of latent heat of vaporizations.

Planning of scientific investigation involves a student devising and describing an experiment to test a given hypothesis. Parnes (1963) and Hudson (1967) suggest that this ability could be displayed in problems that require students to propose and device experiments to test a given hypothesis. In this study students were given a problem entitled 'Root nodule" where they were required to devise an experiment to test the factors affecting root nodule formation in leguminous plants.

2.4 Practical Investigation and Scientific creativity

Previous studies have indicated that scientific creativity can be enhanced through appropriate instructional strategies. The low level of scientific creativity amongst secondary school students have been attributed to inappropriate instructional strategies used by teachers (Okere 1996). He suggested that the learners' scientific creative skills can be improved through the use of instructional strategies which promote learner participation through thinking and contributing to the investigation. For instance problems may be set which require the learners to generate their procedures, suggest apparatus to use and identify sources of errors that may hinder their results.

In this study Practical Investigation Module (PIM) a kind of laboratory approach was used. The module consisted of two parts a problem entitled 'Root Nodule' and a worksheet for students' report. In the Root nodule experiment the students were required to determine the factors affecting the root nodule formation in leguminous plants. The problem was designed in an open ended nature which required students to devise ways of solving it while working in groups of four. The worksheet for the students' report consisted of brief guidelines which guided them on how to report their findings. It consisted of subsections such as name of investigation, hypotheses, dependent and independent variables, control variables, sources of errors and conclusions.

Splinkler (1984) in his study to investigate the effect of open inquiry laboratory approach on learning some concepts in physics found that using inquiry laboratory approach to learn about measurement, pressure, and Archimedes's principle showed greater achievement in some concepts, greater comprehension of all areas taught, and better attitudes towards science than a similar class taught with traditional experimental approach. Leonard (1984) asserts that students can learn better when given fewer procedural directions on laboratory investigations. He adds that the use of investigative approaches in science laboratory has the following advantages; Are more student involving and more inductive than traditional approaches, Contain less directions and give the students more responsibility of determining procedural operations, require students to make more extensive use of science processes skills, produces significantly greater gains than traditional approaches and works equally for all students irrespective of their ability levels not just the very talented.

The biology curriculum in Kenya advocates for inquiry approaches to teaching since it provides students with greater understanding of the concepts they learn and help them to develop skills that they can apply to new situations (Maundu, et al. 2005). However, science teaching in the majority of Kenyan secondary schools is predominantly content first rather than application first (SMASE, 2004). In this respect, students in practical lessons often follow some laid down procedures to confirm laws and principles already established. These kinds of experiments leave students with the impression that scientists also follow predetermined procedures to arrive at their discoveries. Similarly, Runco (2008) asserts that in school science experiments the problem and materials are given to the students which hinder the improvement of creative thinking skills. Moreover scientific knowledge and theories are directly told to the students in their textbooks hence can't think for themselves. On the other hand as the teacher teaches a lesson he/she tells about the concept first and then makes the student do the experiments to understand the concepts. This type of science education does not exactly represent the scientific exploring process (Singh, 2005).

He remarked that if biology instruction is to provide learners with realistic view of science it should provide opportunities and active support for comprehension and application of basic skills to the acquisition of creative abilities. This study aimed at providing the students with the opportunity of applying the science skills of investigation in practical lessons with the aim of developing creative abilities.

3. Methodology

3.1 Population and sample

The population of the study consisted of form three biology secondary school students in Kericho district, Kenya. The sample consisted of 189 students in their intact classes in the four selected schools in the local government area of study. The schools were county boys and girls randomly assigned to experimental and control groups as shown in the table.

Table 1:
Breakdown and characteristics of the sample

Schools	**Gender**	**Number of students**
E1	Boys	47
E2	Girls	50
C1	Girls	47
C2	Boys	45
Total		**189**

3.2 Instrumentation

In order to collect data two instruments were used:

i. Biology Creativity Test (BCT) made up of 8-items open ended questions used during pretest.
ii. Scientific Creativity Test in Biology (SCTB) consisted of 15-items open ended questions used during posttest.

3.3 Validity and Reliability

Specialists in scientific creativity as well as science education in the Department of Curriculum and Instruction at Egerton University moderated the items in BCT and SCTB before pilot testing. The tests were then pilot tested in two secondary schools not included in the main study sample but with similar features as those to be used later on. This was done so as to prevent contamination of study samples and results obtained in the course of the study. The test was scored on the basis of one point for each correct response. The results were used to calculate the difficulty index and discrimination index of the items. Those items with index of between 0.3 and 0.7 were selected. The reliability of the test items was determined using Kuder-Richardson formular (KR-21) and the reliability coefficient of 0.78 was obtained.

4. Results and Discussion

To establish the possible differences of the students in the control and experimental groups Biology Creativity Test was administered as pretest. The scores obtained for each of the creativity aspect were analyzed using t-test and the results are given in table 2 below.

Table2: Comparison of pre-test means of groups E1 and C1 by learning strategy on flexibility, sensitivity, planning and recognition

Variable.	Group.	N	X	SD	df	t-value	sig (2-tailed)
Flexibility in	E1	47	1.43	0.68	92	-0.45	0.653
reasoning	C1	47	1.49	0.68			
Sensitivity to scientific	E1	47	0.81	0.45	92	0.24	0.81
problems	C1	47	0.78	0.41			
Planning of scientific	E1	47	4.45	1.79	92	-0.26	0.79
investigation	C1	47	4.51	1.36			
Recognition of	E1	47	1.57	0.71	92	1.03	0.31
relationships	C1	47	1.42	0.68			

It can be noted from table 2 that the difference between the means of groups E1 and C1 in all the four aspects of scientific creativity were not statistically significant at the beginning of the experiment since p>0.05. This indicates that the students in both experimental and control groups were all at the same achievement level. Thus the sampled students were suitable for the study.

4.1 Testing of Hypotheses

Hypothesis 1: There is no significant difference on students' flexibility in reasoning between the students subjected to Practical Investigation and those not exposed to it.

The posttest scores for the students in the four groups were subjected to ANOVA. The results are given in table 3 below.

Table3: Comparison of flexibility in reasoning post-test means scores using ANOVA

	Sum of squares	df	Ms	F	p-value
Between groups	1797.494	3	599.165	88.007	.000
Within groups	1259.501	185	6.808		
Total	3056.995	188			

F (3, 185) 88.007 p< 0.05

The results indicated that there was a significant effect of Practical Investigation on students' flexibility in reasoning since p<0.05 therefore the null hypothesis was rejected. However in order to establish where the differences between the groups occurred significantly LSD post hoc test analysis was done. The results are given in the table 4.

Table 4: Post Hoc comparisons of the post- test means of flexibility in reasoning

	(I) Group	(J) Group	mean difference (I-J)	P-value
LSD	E1	E2	.674	.078
		C1	6.83*	.000
		C2	8.20*	.000
	E2	C1	2.16*	.000
		C2	3.53*	.000
	C1	C2	.41	.217

*Significance at p< 0.05

From table 4 it can be observed that there were significant differences between groups E1 and C1 (6.83), E1 and C2 (8.20), E2 and C1 (2.16) and E2 and C2 (3.53). The differences between E1 and E2 (0.674) and between C1 and C2 (0.41) were not statistically significant since p>0.05. Hence it may be concluded that Practical Investigation has a significant effect on students' flexibility in reasoning.

Hypothesis 2: There is no significant difference on students' ability to be sensitive to sources of errors in an experiment and control variables between the students subjected to Practical Investigation and those not exposed to it. To test this hypothesis the student's posttest scores were analyzed using ANOVA and the results are given in table 5 below.

Table 5: Comparison of students' sensitivity to scientific problems posttest means scores using ANOVA

	Sum of squares	df	MS	F	p-value
Between groups	47.227	3	15.742	37.297	.000
Within groups	78.085	185	0.422		
Total	125.312	188			

F (3, 185) 37.297 p< 0.05

The results from the table indicate that the differences between the groups were statistically significant hence the null hypothesis was rejected. To identify which of the groups differed significantly post hoc LSD test was done. The results are given in table 6 below.

Table6: Post Hoc comparisons of students' sensitivity to scientific problems posttest means scores

	(I) Group	(J) Group	mean difference (I-J)	P-value
LSD	E1	E2	.764	.083
		C1	1.19*	.000
		C2	1.26*	.000
	E2	C1	.286*	.000
		C2	.357*	.000
	C1	C2	.071	.599

*Significance at p < 0.05

It can be noted from table 6 that the differences between the means of C1 and C2 (0.714) and E1 and E2 (0.764) were not statistically significant (p>0.05). However, the differences between E1 and C1 (1.192), E1 and C2 (1.26), E2 and C1 (0.28) and between E2 and C2 (0.358) were all significant. Hence it could be concluded that Practical Investigation has a significant effect on students' ability to be sensitive to sources of errors in an experiment and control variables.

Hypothesis 3: There is no significant difference on students' ability to plan for scientific investigation between the students subjected to Practical Investigation and those not exposed to. This was tested by subjecting students' posttest scores to ANOVA. The results are given in table 7 below.

Table 7: Comparison of students' ability to plan scientific investigation posttest means scores using ANOVA

	Sum of squares	df	MS	F	p-value
Between groups	1530.074	3	510.025	106.533	.000
Within groups	885.683	185	4.787		
Total	2415.757	188			

F (3, 185) 106,533 P<0.05.

The results from the table indicated that the difference were statistically significant hence the null hypothesis was rejected. In order to determine the groups that were significantly different LSD post hoc pair wise comparison was done. The results obtained are given in table below.

Table8: Post Hoc comparisons of the posttest means of students' ability to plan for scientific investigation

	(I) Group	(J) Group	mean difference (I-J)	P-value
LSD	E1	E2	4.13*	.002
		C1	6.38*	.000
		C2	7.50*	.000
	E2	C1	2.24*	.000
		C2	3.37*	.000
	C1	C2	.629	.123

* Significance at p<0.05

The results from table 8 indicated that there were significant differences between the means of groups E1 and C1 (6.38), E1 and C2 (7.50), E2 and C1 (2.24) and E2 and C2 (3.37). The difference between groups C1 and C2 (0.629) was not statistically significant. Thus it may be concluded that Practical Investigation has a significant effect on students' ability to plan for a scientific investigation. However the significant difference noted between groups E1 and E2 (4.13) may be attributed to the fact that planning is an aspect of scientific creativity that measure design of investigation and not knowledge dependent. Thus, student's participation and interest influences the development of this skill. Similarly it may be attributed to the differences in schools' characteristics such as the rigid programs geared towards exam oriented kind of education system.

Hypothesis 4: There is no significant difference on students' ability to recognize relationship between general observations and scientific concepts between the students subjected to Practical Investigation and those not exposed to it. This was tested by subjecting the students' posttest scores on recognition to ANOVA. Results are given in table 9 below.

Table 9: ANOVA of posttest means of students' ability to recognize relationships between general observation and scientific concepts

	Sum of squares	df	MS	F	p-value
Between groups	96.937	3	32.312	27.741	.000
Within groups	215.486	185	1.165		
Total	312.423	188			

$F(3, 185)\ 27.741 \quad p < 0.05$

From the table it can be noted that the differences between the groups were statistically significant. However in order to establish the groups that differed significantly LSD post hoc pair wise comparison was done. The results are given in table 10.

Table 10: Post Hoc pair wise comparisons of students' ability to recognize relationships between general observations and scientific concepts posttest means scores

	(I) Group	(J) Group	mean difference (I-J)	p-value
LSD	E1	E2	1.52	.061
		C1	1.68*	.000
		C2	1.30*	.000
	E2	C1	.117	.593
		C2	.493*	.000
	C1	C2	.629	.123

*Significance at $p < 0.05$

It can be observed from table 10 that the differences between E1 and C1 (1.68), E1 and C2 (1.30) and E2 and C2 (0.493) were all significant. The differences between E1 and E2 (1.52) and between C1 and C2 (0.629) were not statistically significant (p>0.05). Hence may be concluded that Practical Investigation has a significant effect on students' ability to recognize relationships between general observations and scientific concepts. However the lack of significant difference between groups E2 and C1 (0.117) noted may be attributed to the fact that recognition aspect of scientific creativity is knowledge dependent. It involves a learner retrieving earlier learned scientific concepts and applying them in other areas. The degree to which the content was covered and understood by the learner affects how she/he will apply them in a novel situation.

5. Discussion

5.1 Flexibility in reasoning

To determine student's flexibility in reasoning they were subjected to a set of seven questions that required them to give a variety of responses as much as they could on how a given problem could be solved. Those who gave more and relevant responses were found to be more flexible in reasoning than those who gave less. It was found that the students who had been subjected to Practical Investigation performed much better than those who were using the Conventional Laboratory approach. This means that by giving learners an opportunity to carry out scientific investigation on a given scientific problem enhances their flexibility in reasoning thus promoting their scientific creative skills. These findings agree with Haigh's finding (2007) where he found that Investigative Practical approach enhanced scientific creativity. In addition Pink (2005) pointed out that teaching students to solve problems that do not have well defined answers foster scientific creativity. The scientific creativity aspect of flexibility in reasoning was found to be well performed by all categories of the learners. This could be attributed to the fact that flexibility is an aspect of scientific creativity that measure design of investigation and not knowledge dependent hence performance of the subjects largely influenced by the characteristics of the school environment. This finding is in agreement with that of Ndeke (2003) who found that flexibility was better performed than other aspects of scientific creativity. This suggests that even those students who don't perform well in biology and sciences in general can develop scientific creative abilities.

5.2 Sensitivity to scientific problems

Sensitivity to scientific problems refers to the ability of a student to identify sources of errors in an experiment and also suggests the control variables. The findings in this study revealed that most students were not able to tackle such questions. This may suggest that little is done in the classroom or laboratory lesson to promote this skill. Similar findings were also obtained by Okere (1996) who pointed out that such questions pose some difficulties to students could be because they are rarely asked to explain possible sources of errors that are likely to affect the experimental results. Ndeke (2003) also made the same observation that question testing the sensitivity aspect of scientific creativity were poorly performed probably because teachers do not include activities that enable learners to be sensitive to scientific problems. However the students who had been subjected to Practical Investigation performed much better than those who used Conventional laboratory approach. Thus this means that appropriate instructional approach when used enhances students' sensitivity to scientific problems. Abuto (2005) findings also made similar observation that concept mapping teaching strategy enhances students' sensitivity to scientific problems.

5.3 Planning of scientific investigation

To determine the student's ability to plan for scientific investigation the students were given a set of problems that required them to suggest the apparatus that they would use, methods of checking the results and the control variables. This aspect was well performed by all the learners both in the experimental groups and the control groups. However those in experimental group performed much better than the control groups. Although the experimental groups also differed this could be due to the fact that planning aspect largely depends on personality, motivation and environment. Hu and Adey (2002) pointed out that the scientific creativity of individual secondary school student within a given school system is influenced by the creative environment. This suggests that even if the instructional method used is appropriate in promoting scientific creativity the school environment affects the development of the skill of planning for scientific investigation.

5.4 Recognition of relationships between general observation and scientific concepts

To determine the student's ability to recognize relationships between general observations and scientific concepts the students were given a set of questions describing certain general observations and they were required to relate to some scientific concepts they had learned in biology. The performance in such questions varied greatly depending on the academic performance of their schools. This suggests that recognition aspect is knowledge dependent. Ndeke (2003) in her studies found a high correlation between biology achievement test and recognition aspect indicating that a good mastery of biology content is essential for effective recognition of relationships. These findings agree with that of Okere (1986) that physics knowledge contributes to scientific creativity of secondary school students. These findings imply that using appropriate instructional approach only that enhances scientific creativity may not be sufficient enough in enabling students to recognize relationships between general observations and scientific concepts. The students should be well equipped with relevant scientific concepts so as to be able to retrieve and relate accordingly.

6. Conclusion

Based on the findings of the study it was concluded that Practical Investigation laboratory approach enhances scientific creativity amongst secondary school biology students. However in order to achieve this students should be given an opportunity to carry out scientific investigation on a given problem rather than being given a list of procedures to follow in solving the problem. This would enable them to explore several ways of getting a solution consequently enhancing their flexibility in reasoning. Similarly questions that require students to site sources of errors and control variables in an experiment should be included in the examinations so as to promote sensitivity aspect of scientific creativity. The learning environment should also be designed in such a way that it motivates the learners, it arouses their interests and enables them to participate in learning activities. This is because this and previous studies have indicated that the school environment affect the degree of students' scientific creativity. Lastly the learners should be equipped with the correct and relevant knowledge of the subject matter.

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