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Relationship between Science Process Skills Approach and Learners' Creativity Level in Biology in Secondary Schools in Makueni County, Kenya

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Abstract
Biology makes students aware of the nature of their daily life, and the care and protection of the environment. This study looked at a relationship between the Science Process Skills Approach and learners' creativity levels in biology in secondary schools of Makueni County, Kenya. It was prompted by the observation that, the students' academic achievement in biology had remained persistently low due the low creativity levels. The teaching of the abstract nature of the biology concepts had remained teacher-centered. The objective of the study was to establish the difference in learners' creativity levels in biology of students taught using Science Process Skills Approach and conventional methods. The research was based on constructivism and experiential learning theories. It adopted quantitative research methodology and Quasi-Experimental Research Design involving Solomon's Four Non-Equivalent Control Group Design. The accessible population was Form Two Biology students within Makueni County. A stratified sampling procedure was used to assign the co-educational secondary schools and purposive sampling was for the selection of the four Sub-Counties in which only one school per the sampled Sub-County was sampled for purposes of the study. The sample size was 204 Form Two students who were purposively selected from the county. SPSA was the intervention for the two experimental groups and conventional methods for the control groups. Biology Assessment Test (BAT) measured the students' creativity levels. Research experts from the department of educational communication and technology of Machakos University and two experienced biology teachers validated the instrument. The reliability test used the split-half reliability through the KR-20 formula at $\alpha = 0.860$. Statistical package of social sciences (SPSS) version 21.0 was used to analyze the collected data. Analysis used descriptive and inferential statistics. Descriptive statistics calculated mean scores, and standard deviations while inferential calculated t-test, ANOVA, ANCOVA, and Post-Hoc Scheffe Multiple Comparisons tested the hypothesis at α 0.05. The findings of the study demonstrated that SPSA enhanced students' creativity levels in biology. It was hoped that the results of the study would provide useful information about students' creativity levels to biology teachers, curriculum developers, Quality Assurance and standards officers (QASO), and teacher-trainers.

Keywords: Kenya, Secondary Schools, Makueni County, creativity, science, process, skills, Biology

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Relationship between Science Process Skills Approach and Learners' Creativity Level in Biology in Secondary Schools in Makueni County, Kenya

By

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1.0. Introduction

In several occasions, the emphasis of the development of science process skills and scientific knowledge among the learners has been the major objective of science education (Adeyemi, 1990; Urevbu, 1990). This provokes the need to prepare science educators effectively to deliver the secondary school science curriculum in a way that enables the students to develop scientific knowledge and become more creative. Sciences comprise chemistry, biology, and physics, which have been poorly, performed (KNEC, 2020).

Learning biology through doing engages students, tests their ideas, and builds their understanding fast than when they learn by hearing or reading (Ewers, 2001). Therefore learning biology may require hands-on, minds-on, and hearts-on activities that can provide the students with the ability to discover and transform information, and check new information against old. The Science Process Skills Approach has activities that have hands-on, minds-on, and hearts-on activities to bring awareness about the secondary school biological concepts (McNeill, 2009).

The problem of poor performance in biology is global as indicated by Landry (1998) in Canada, and Fonseca and Conboy (2006) in Portugal. Mullis, Martin, Foy, and Arora (2011) found out that USA learners were significantly below than those of Singapore and Chinese. The poor performance was attributed to lack of learners' interest and poor teacher preparedness in the teaching methods (TIMSS, 2003).

In Nigeria, learning biology enables students to understand their environment; acquire biological knowledge applicable in fields like Medicine, Biochemistry, Pharmacy, Microbiology, and Agriculture among others. WAEC (West African Examinations Council, 2012; 2013 & 2014), revealed that only 49%, 38.5%, and 35.66% respectively got quality scores in the biology examinations, the rest got low scores due to the nature of teaching methods used, availability of laboratories, and other teaching facilities in their right number as per the number of students taking biology.

In Kenya, biological knowledge is used to develop high-yielding, disease-resistant, and fast-maturing food crops and animals to meet the food requirements for the nation. Despite biology being a key subject in Kenyan secondary schools' education, the Kenya national examinations council indicates poor achievement in the Kenya certificate secondary education (K.C.S.E) than any other subject (KNEC, 2019) as in table1.

Table1: Summary of Biology KCSE Candidates' Overall Performance in Kenya from 2016-2020

Subject	Biology		Physics		Chemistry	
Year	Mean Score	SD	Mean score	SD	Mean Score	SD
2016	58.37	35.16	79.53	42.40	47.42	32.47
2017	37.85	23.45	70.09	39.59	48.09	32.80
2018	51.38	23.26	68.54	35.31	53.76	33.45
2019	51.38	23.26	65.18	33.96	52.17	32.71
2020	53.03	29.50	71.03	35.03	45.01	30.19

Source: KNEC, (2020).

The mean scores for biology and chemistry tend to be too low and biology in 2017 showed the poorest performance (KNEC, 2020). Thematic learning-rich with varied group activities, discussions, and active learning about the biological concepts is linked to creative exploration. The learner-centered teaching and learning approaches actively engage the learners, make them master the subjects' content better, and increases their creativity levels (Ministry of Education Science and Technology, (MoEST) 2001). The study investigated

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how the use of the SPSA improves creativity levels in biology in secondary schools of Makueni County.

1.1: Statement of the Problem

The government of Kenya has committed itself to improving the quality of biology and particularly the learners' creativity levels. However, there has been persistent National, County, and Sub-County outcry about the low learning achievement in biology at the secondary school level due to low creative levels which has had a greater threat to biology-related careers. Attempts by researchers and interventions through workshops, seminars, and in-service training had been made on how to counter the low creativity levels in biology but no significant improvements had been recorded due to continued low performance. One of the key factors leading to low learners' creativity levels had been noted to be the non-innovative and teacher-centered teaching approach adopted by the teachers as they teach the abstract nature of biology concepts. Much of the teaching done allowed the learners to memorize the information leading to a low retrieval rate hence the low achievement in students' creativity levels in biology. The study investigated how the lack of learners' exposure to Science Process Skills Approach that contributes to low levels of learners' creativity in biology. Students had displayed low levels of creativity that improved when the teachers used the SPSA and the respondents of this study.

SPSA from several researchers is among the most powerful tools for producing and arranging information in several subjects and it helps the students to conceptualize concepts at a much deeper level as well as make them know and equip themselves with the skills for acquiring future new knowledge. Despite the above findings, little by the time of this study had been done on how the use of the SPSA has greater improvement towards learners' creativity, levels. Therefore, this study targeted to investigate the relationship between the SPSA and the learning achievement in biology in secondary schools of Makueni County, Kenya.

1.2: Purpose of the Study

The purpose of the study was to investigate the relationship between the Science Process Skills Approach and learners' creativity, levels in biology in secondary schools of Makueni County, Kenya.

1.3: Objectives of the Study

The specific objectives of the study was to establish the difference in learners' level of creativity in the biology of students taught using Science Process Skills Approach and those exposed to the conventional methods.

1.4: Research Hypothesis

The hypothesis of the study was, there is no statistically significant difference in biology students' creativity levels between those exposed to the Science Process Skills Approach and those exposed to conventional methods in Makueni County.

1.5: The Rationale of the Study

Science process skills are a set of intellectual skills that use scientific activities, which the learners learn and develop during the learning process. Hodson (2005), suggests that when students' interests are captured through hands-on, minds-on, and hearts-on activities that involve the SPSA their creativity levels increases. The study focused on SPSA because it allows students to be actively involved and increases their creativity levels in biology. Quasi-Experimental Research Design was used to avoid randomizing the schools because most of the Kenyan secondary schools are intact groups of classes in nature which the principals would not wish to break for the purposes of study. The design assisted to find out the effects of the SPSA interventions to the treatment groups and controlled the major threats to internal validity. It was against the background that little if any research had been done on the relationship between SPSA and the students' creativity levels in biology in secondary schools of Makueni County, Kenya that this study was carried out.

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2. 1: Teaching Strategies in Biology

The teaching strategies in biology have experienced a significant shift with efforts to meet the individual student's needs (Helikar, Cutucache, Dahlquist, Herek, Larson, & Rogers, 2015). They have become more interactive and activity-based allowing learner participation and engagement. Use of student-centered teaching strategies leads to significant improvement of the students' scores and their views towards biology (Connell, Donovan, and Chambers 2016). Learner-centered strategies have the components of the SPSA like planning process, implementation, and assessments of their learning referred as science process skills.

2. 2: Science Process Skills

Karsli and Alipasa (2014), define science process skills as the adoption of skills used to compose knowledge, identify a problem, think about it, look for solutions, and make conclusions. According to Ibrahim, (2015) these skills are achieved through hands-on, minds-on, and hearts-on activity-based learning processes, which make the learner self-driven. It is the responsibility of the teacher to prepare and guide the learners towards the use of hands-on activities to improve their creativity levels in biology. They awaken and stir student-reasoning abilities toward problem solving and improve their perception and understanding of concepts during learning experiences (Ozgelen, 2012). This study focused on selected science process skills to find out how they improve learners' creativity in biology.

2. 3: SPSA and Creative Skills

Creativity is a mental activity made to produce new extraordinary and unique ideas (Beghetto & Kaufman, 2010). A creative person has; problem-solving skills, the capability of self-evaluation, self-assessment, logical thinking, and a high rate of visualization (Starko, 2013; Ward & Kolomyts, 2010). Students become creative in their ideas and products as they use their science process skills to look for solutions to the problem they have identified. The learners who learn how to think creatively and develop new ideas from scientific learning are said to have high abilities to apply the skills in their working areas (Meador, 2003). Creative learners build confidence in any acquired information since it is from within their initiatives. Studies by psychologists on creativity have shown little concern about scientific creativity gained through Science Process Skills Approach and that the scientific knowledge and theories are directly told to the students as they appear in their textbooks as cited by Mansfield and Busse in Liang (2002). This study looked into the extent to which the use of the SPSA improves the students' creativity levels in biology.

2. 4: Theoretical Framework

The study was based on Constructivism and Experiential learning theories. The Constructivism Learning Theory by Dewey as cited in Gutek, (2014), Vygotsky, (1998), and Piaget (1980), views the learner as a constructor of new knowledge. The learner taught to be creative, and with an open mind for the effective construction of knowledge to be achieved. Experiential Learning Theory from the work of Dewey as cited in Gutek (2014), Piaget (1980), and Lewin cited in Smith (2001) perceives the learner to be in a position to build new knowledge from experiences.

2. 5: Conceptual Framework on the Relationship between the SPSA and Learners' level of creativity in Biology.

In Figure1 the teaching Methods are the independent variables. The research adopted the SPSA to find out its relationship with the learners' level of creativity, which is the dependent variable. The intervening variables included Teaching/learning resources, Parental support to education. School policies and Learner's entry behavior. Teaching and learning of sciences require more blended learner-centered approaches that can improve the experienced low achievement in Biology in the Kenyan secondary schools.

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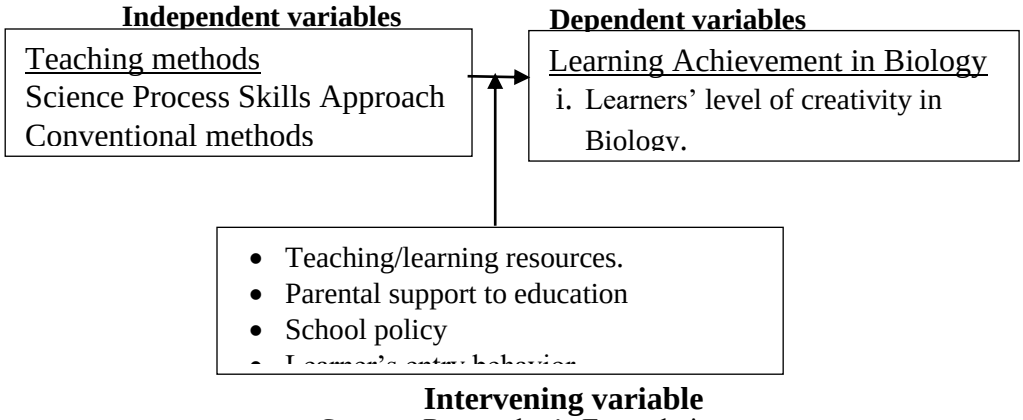

Source: Researcher's Formulation

Figure1: Showing Conceptual Framework on the Relationship between the SPSA and Learners' level of creativity in Biology

3. 0: Research Methodology and Design

The research adopted a quantitative research method to provide numerical data from the standardized BAT. The study used a Quasi-experimental Research Design involving Solomon Four Non-Equivalent Control Group Design as studied by Borg and Gall cited by Githua and Nyabwa (2008). In this study, a Quasi-Experimental research design was used to evaluate the teaching interventions of the SPSA against the conventional methods because of the intactness of the classes and the students were not randomized. The study adopted the Solomon Four Non-Equivalent Control Group Designs that represented in Figure 2

Group	Pre-test	Intervention	Post-test
Group 1 (E1)	T1	RX	P1
Group 2(C1)	T2	-	P2
Group 3(E2)		RX	P3
Group 4(C2)		-	P4

Source: Best and Khan, (2003).

Figure 2: Solomon Four Non- Equivalent Control Group Design

The design was adopted to avoid randomization of the intact classes, to compare the effect of the interventions to the treatment groups with the control groups, and control major threats to internal validity Best & Khan, (2003). The study adopted the symbols C1 and C2 for control groups exposed to conventional methods, and E1 and E2 to represent Experimental groups exposed to SPSA Wiersmal (2000). T1 and T2 represent the pre-test given to E1 and C1 groups while a post-test examination labeled P1, P2, P3, and P4 administered to all groups after the intervention. Rx represented the intervention or treatment by use of the SPSA. (-) implies no intervention to C1 and C2 was given (Mugenda & Mugenda, 2003). The dotted lines between the groups indicated the intactness of the groups used in the study and therefore there was no need of randomizing the students when establishing the experimental and control groups. The target population was 119,225 secondary school biology students of Makueni County with the accessible population as 31, 574 Form Two Biology students. (Makueni County Education Offices KCSE KNEC report, 2020). Form Two Students were the choice for this study because of the one-year's exposure to secondary schools' science curriculum, and adjustment they had to the secondary schools' education.

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3. 1: Sampling Procedure and Sample Size
This study adopted purposive sampling to select the four co-educational Sub-County public secondary schools. Purposive sampling refers to a non-probability sampling technique in which the representative samples are obtained through judgments (Tashakkori & Teddlie, 2003). Four out of the 322 Sub-County co-educational secondary schools were sampled which gave 204 students.

3.2: Research Instrument
A research instrument is a device used to collect information (data) to answer the research questions for any study (Fraenkel & Wallen, 2000). The most popularly used tools in assessing learning achievements have been standardized achievement tests, (Haladyna, Downing, & Rodriguez, 2002). Biology Assessment Test (BAT) tested learners' creativity levels to provide quantitative data from learners' scores. Its questions ranged from high to the low creativity order as per revised Bloom's taxonomy (Seaman, 2011). Computation of the learners' mean scores in the section measured the creativity levels of the learners which were valued as either; highly, moderately, or less.

3.3: Instrument Validity and Reliability
Fraenkel and Wallen, (2014), define validity as a measure of how correct inferences are made based on the results from the research instrument, the instrumentation process, and the characteristics of the group studied. Research experts did validation in this research from the Department of Educational Communication and Technology of Machakos University in the School of Education and two biology-trained teachers with more than ten years teaching experience and more than five years marking experience with Kenya National Examinations Council (KNEC). Mugenda and Mugenda, (2003), define reliability is the measure of the degree of consistency of results or data after repeated trials during a study from a research instrument. Reliability was by use of the split-half technique, which identified all misconceptions, and ambiguity of the questions and a reframing was done.

4.0: Results and Discussions
Pre-test scores of C1) and E1 from the BAT were analyzed to find out the homogeneity of the groups before the study.

Table 3: Pre-Test Mean Score on Creativity

Pre-Test	Groups	N	Mean	Std. Deviation	Std. Error Mean
Creativity	E1	53	6.85	5.146	.707
	C1	54	7.04	4.157	.566

Source: Field Data 2022

Pre-test mean scores for C1 and E1 of 7.04 and 6.85 respectively gave very small difference between the two groups. An independent sample t-test of pre-test scores on creativity based on groups E1 and C1 was done to determine whether the differences were statistically significant or not at the level of α=0.05

Table 4: Independent sample t-test of pre-test scores on creativity based on groups E1 and C1

Test	Group	N	Mean	SD	Df	t-computed	t-critical	*p*-value
BAT	C1	54	7.04	4.157	105	0.836	1.98	0.101
	E1	53	6.85	5.146				

*Not significant at p>0.05 level
*Critical values (df= 120, t=1.98, *p*>0.05) Calculated values (df=105, t=0. .836, *p*=0.101)
t -computed< t-critical
Not significant at α=0.05 level
Source: Field Data 2022

Results in Table 4 showed E1 and C1 to have t-computed at 0.836, which is lower than the t-critical value of 1.98. The *p*-value of *p*=0.101 is greater than the significant level of α=0.05 hence the two groups were similar in their creativity levels and at the start of the study. The hypothesis of this study sought to find out whether there was any statistically significant difference in students' creativity levels between those exposed to the SPSA and those exposed to the conventional methods.

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Table 5: Creativity Post-Test Mean Score and Standard Deviation for the Four Groups after Intervention.

Groups	Mean	N	Std. Deviation
E1	13.36	53	6.070
C1	9.93	54	4.770
E2	13.44	52	4.522
C2	9.40	45	5.006
Total	11.60	204	5.426

Source: Field Data 2022

E1 and E2 exposed to SPSA achieved higher mean scores of 13.36 and 13.44 respectively than the control groups C1 that had 9.93 and C2 9.40. The findings are in line with the results of Okere, ((2002) whose experimental groups attained better mean scores in the subject tested than the control groups exposed to the conventional methods. One- Way ANOVA gave a statistically significant difference between the experimental and the control groups at α=0.05.

Table 6: One-Way ANOVA of the Post-Test Scores on the creativity

	Sum of Squares	Df	Mean Square	F- computed	t- critical	*P*-value
Between Groups	709.520	3	236.507	8.980	2.6519	0.000
Within Groups	5267.519	200	26.338			
Total	5977.039	203				

*Significant at $p \leq 0.05$ level
*Critical values (df= (3, 200), t=2.6519, $p<0.05$) Calculated values (df= (3,203) F=8.980, $p=0.000$),
F- Computed> t-Critical,
Significant at $p \leq 0.05\alpha$ level.
Source: Field Data 2022

Table 6 indicates that a statistically significant difference existed between the groups at $P<0.000$ below α=0.05 hence the null hypothesis no statistically significant difference in biology students' level of creativity between those exposed to the SPSA and those exposed to conventional methods rejected. These findings did not indicate which groups are similar, which are different, and therefore, it was necessary to carry out Least Significant Difference (LSD) on creativity to know which groups were statistically significantly different as in Table 7.

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Table 17: Post-Hoc Scheffe Multiple Comparisons of SPSA Creativity Post-test Means for Four Groups

(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	Sig.
E1	C1	3.433*	.992	.009
	E2	-.084	1.002	1.000
	C2	3.958*	1.040	.003
C1	E1	-3.433*	.992	.009
	E2	-3.516*	.997	.007
	C2	.526	1.036	.968
E2	E1	.084	1.002	1.000
	C1	3.516*	.997	.007
	C2	-4.042*	1.045	.002
C2	E1	-3.958*	1.040	.003
	C1	-.526	1.036	.968
	E2	4.042*	1.045	.002

The mean difference is significant at the 0.05α level
Source: Field Data 2022

E1 Verses C1 were significant at 0.009α level, E1 Verses C2 at .003α, C1 versus E2 at .007 α, E2 versus C2 at 002 α which were all below 0.05α. This suggests that the differences were due to the intervention of the SPSA that was superior to conventional methods. There was no statistically significant difference at 0.05α level between E1 versus E2 and between C1 and C2. The results were confirmed using the ANCOVA. ANCOVA reduces the effects of initial group differences statistically by making compensating adjustments to the post-test means of the groups used in the study Wilcox (2015).

Table 8: Analysis of Covariance (ANCOVA) of the Creativity Post-test Scores of SPSA with Pre-test as the Covariate

Source	SS	Df	MS	F	*P*
adjusted means	322.37	1	322.37	11.1	0.001196
adjusted error	3019.29	104	29.03		
adjusted total	3341.65	105			

*Significant at $p < 0.05$α significant level,
*Critical values (df= (1, 105), F=3.936, $p<0.05$) Calculated values (df= (1,104), F=11.1, p=0.001196), F- Computed > F-Critical
Source: Field Data 2022

The results in Table 8 showed a significant difference between the mean scores of E1 and C1, at p=0.001196 below α=0.05. E1 taught using SPSA performed better than those who were taught through conventional teaching methods, and therefore, the null hypothesis was rejected.

5.0: Conclusions

The use of the SPSA increased the students' creativity levels evidenced by the significantly high BAT mean scores noted in the experimental groups than the control groups. Therefore, students stand to benefit more in learning biology when exposed to SPSA than the conventional methods. These results offered a departure of the teaching approach from the conventional methods to the more learner-centered SPSA that makes the learners active in the learning process.

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5. 1: Recommendations of the study

Based on the results of this study, SPSA improved the learning achievement in biology in the Co-educational Secondary Schools of Makueni County. Therefore, it was recommended that:

i. Biology teachers ought to incorporate SPSA in the teaching-learning process to improve the learners' creativity levels.
ii. The biology teachers should assimilate the SPSA activities in the teaching of biology to improve the students' creativity levels.
iii. All public teacher training institutions, Ministry of Education in-service organized courses like CEMASTEA, TPDP, and CBC workshops, NGO like KICD, Jomo Kenyatta Foundations should incorporate the SPSA in their teaching programs to get quality modern teachers ready to improve the creativity levels of their students.

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