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The Effect Of Inquiry-Based Science Teaching Approach On Scientific Creativity Of Secondary School Physics Students In Kitui County, Kenya

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Abstract: ***The present study was prompted by the consistent posting of dismal performance in Physics in Kenya in general and Kitui County in particular as shown by the annual KNEC reports on KCSE performance for the period 2014-2019. The study set out to investigate the effect of Inquiry-Based Science Teaching Approach on learners' scientific creativity of secondary school physics students in Kitui County, Kenya. The guiding objective was to establish the difference in Scientific-Creativity between students taught using Inquiry Based Science Teaching Approach and those taught using the conventional methods. The study was anchored on both the Constructivist and the Self-Determination Theory. It adapted a mixed methodology and a Quasi Experimental Research Design and in particular the Solomon's Four Non-Equivalent Control Group Research Design. The target population was 1600. A sample size of 160 respondents was used. Purposive and Stratified random sampling techniques were used to select the study participants. The research instrument used was a students' scientific observation schedule with a reliability coefficient of 0.723. Descriptive analysis was done by use of frequencies, means, standard deviation and percentage while the inferential analysis used the Analysis of Variance, and the Least Significant Difference (LSD) technique at a significance level of coefficient alpha α=0.05. The findings showed a statistically significant difference in scientific creativity between students taught using IBSTA and those taught using conventional methods. The study concludes that IBSTA is effective in improving students' self-concept. The key recommendation of the study is the creation of an enabling environment for IBSTA adoption in schools.***

Keywords: ***Conventional Teaching Approach, Critical Thinking, Inquiry Based Science, Teaching Approach, Learning outcome, Scientific Creativity:***

I. INTRODUCTION

Inquiry-Based Science Teaching Approach is a method that combines the curiosity of students and the scientific method, which enhances the development of scientific creativity while learning, physics (Hesson, & Shad, 2007). Inquiry-Based Teaching Approach provides the input of the student with a problem to investigate along with the procedures and materials (Bulbul, 2010). The goal is for the students to use their observations and prior knowledge to build conclusions that the teacher wants them to understand. Inquiry-Based Learning is the best method to use in order to create a student centered learning environment. This is according to a case study in United State of America by Marshall, Smart& Horton, (2010). Inquiry based Learning is regarded as an approach which is student-centered and which supports the configuration of knowledge (Koseogly & Tumay, 2010). According to a study conducted in Boston by Bausal (2006), the findings indicated that the use of Inquiry-Based Learning, presents students with opportunities to ask

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questions, seek answers, analyze data, discuss ideas and apply their scientific creativity in a variety of contexts to describe and explain phenomena. He further reported that teachers who use Inquiry-Based Learning enhance achievement through exposing students to creativity. According to Christopher (2014), Discovery Teaching Approach encourages scientific creativity and discourages plain retention of facts. Changeiywo & Itungi (2009) reported that the knowledge function is a pre-requisite to creative production in Physics and scientific creativity has a great relationship with academic achievement.

STATEMENT OF THE PROBLEM

Creativity among Physics students has been found wanting for a long period (KNEC Reports 2014 to 2019). Some researchers suggest the need to adopt new teaching approaches. Several initiatives have failed to pinpoint a solution. There is currently limited information on the effect of the Inquiry Based Science Teaching Approach (IBSTA) on students' creativity in physics especially in Kitui County. In an attempt to bridge this gap, the current study investigated the effect of Inquiry-Based Science Teaching Approach on the scientific creativity of secondary school physics' students in Kitui County, Kenya.

PURPOSE OF THE STUDY

The purpose of this study was to investigate the effect of Inquiry-Based Science Teaching Approach on the scientific creativity of secondary physics students' in Kitui County, Kenya.

OBJECTIVE OF THE STUDY

The objective of this study was to establish the difference in Scientific-Creativity of the student taught using Inquiry-Based Science Teaching Approach and those taught using conventional methods in Physics.

HYPOTHESIS

H_{01}: There is no statistically significant difference in Scientific-Creativity in learning Physics between students exposed to Inquiry-Based Science Teaching Approach and those exposed to conventional methods ($\alpha = 0.05$).

II. LITERATURE REVIEW

Inquiry-Based learning posts a positive impact on learner creativity that enhances good performance in science. A study conducted in New-Yolk by Atkinson (2006) on rescuing narrative from qualitative research, showed that Inquiry learning makes a learner gain critical thinking skills. Teachers' beliefs about creativity can influence whether and how they teach for creativity in their classroom instruction (Beghetto & Kaufman, 2014). Kirschner et al (2006) reported that Inquiry Teaching positions a learner to long term and working memory.

According to Herman and Knobloch (2006), Inquiry Based Teaching enhances learner's scientific creativity that makes learners to achieve academically in physics. They also reported that students preferred this instruction method because they are actively involved and responsible for their own educational process. A punitive environment undermines learning by heightening anxiety and stress, placing extra demands on working memory and cognitive resources, which drains energy available to address classroom tasks (Pennington, Heim, Levy, & Larkin, 2016). In Hong Kong, Cheng (2010) researched on impact of the use of Inquiry Teaching Approach on learners' creative thinking. In his finding, he indicated that the teaching approach in science stimulates learners' creativity. It also improves learner divergent thinking and strengthen student problem solving skills.

Ochu (2015) reported that teachers who do not apply Inquiry-Based Learning in laboratory, the learners have a great challenge of being scientifically creative, but for those teachers who attend science workshops and apply the new knowledge; their learners are very creative and imaginative. A research in Uganda by Ssempala (2017) indicated that schools whose teachers have been taken to training on teaching using inquiry based learning, have applied, in their schools, it has enhanced creativity to the learners. Inquiry-Based learning in integrated with teaching aids during the lesson it makes learning interesting and enhances scientific creativity and divergent thinking (Ogwa, 2012). In a case study in Zambia by Mumba (2010), was reported that the use of inquiry based learning build learner's creativity, motivates and makes them have confidence in learning science.

Practical activities in Biology enhance Inquiry skills that stimulate learners' scientific creativity, according to a research by Chumo, (2014). The findings also agreed with that conducted by Ndeke (2009) which indicated that knowledge in science is necessary but not sufficient condition for creativity. Illa & Changeiywo (2010), who reported that there was a positive correlation between learner creativity in Physics and achievement, also supported their arguments. It was discovered from the literature review, vast information exists on effects of the use of Inquiry-Based Teaching Approach in Geography, Chemistry, Mathematics and Biology but there is limited information on effect of Inquiry Based Teaching Approach on learners' scientific creativity. The study investigated the effects of Inquiry-Based Teaching Approach on secondary school Physics students' scientific creativity in Kitui County.

THEORETICAL FRAMEWORK

The study was anchored on two theories: Constructivist Theory of learning and Self-Determination theory. These Theories provided comprehensive but complementary perspectives on Inquiry Based -science-teaching School.

CONSTRUCTIVIST THEORY

This study was guided by Dewey's (1938) Constructivism Theory which upholds that knowledge is actively constructed by organizing subjects not passively received from the

environment (Lerman, 2012). The rationale for using this theory was based on the fact that majority of students have difficulty engaging in constructive learning because they fail to make adequate connections that are necessary in arriving at a desired understanding without hypothesizing and questioning, as is the practice in physics classrooms currently.

SELF-DETERMINATION THEORY

The study was also guided by Deci & Ryans' (1985) Self-Determination Theory which focuses on the degree to which an individual's behaviour in self-motivated and self determined. The theory was found relevant to this study as it guided the researcher to describe the complexity of secondary school Physics teaching by investigating the effect of inquiry based teaching approach on secondary school Physics students' scientific creativity as a learning outcome. This theory was used to anchor the study because Inquiry-Based Science Teaching Approach in teaching Physics involve Engagement, Explanation, Exploration, Elaboration and Evaluation in order to understand a concept.

III. RESEARCH METHODOLOGY

The study used Mixed Methodology that combines quantitative and qualitative research approaches for the aim of breadth and depth of apprehension and certification.

RESEARCH DESIGN

The study applied Quasi-experimental research in which the researcher used Solomon's Four, Non-Equivalent Control Group Design. The design identified a comparison group that was as similar as possible to the treatment group in terms of characteristics. Hence, the method can be said to have caused any difference in outcomes between the treatment and control groups, (Khandker, Shahidur R., et al. 2010).

Group	Design	Group	Pre-test	Treatment	Post-test
I	Experimental	E1	O_1	X	O2
II	Control	C1	O_3	-	O4
III	Experimental	E2	-	X	O5
IV	Control	C2	-	-	O6

Table 1: Solomon's Four Non-equivalent Control Group Design (as Adapted from Shuttle worth, 2009)

SAMPLING PROCEDURE AND SAMPLE SIZE

Stratified random sampling technique was used to select 2 Extra-County Boys Schools and 2 Extra-County Girls Schools out of the 40 Extra-County Schools in Kitui County. Purposive sampling was employed to select Form four students taking Physics at KCSE level in each of the selected schools. Simple random sampling was used to assign groups to experimental groups (E_1 & E_2) each with 40 students and control group (C_1 & C_2) also with 40 students each. Purposive sampling was used to select a teacher from each of the two sampled schools who taught the control groups using conventional methods.

RESEARCH INSTRUMENTS

The instrument used for this study was Scientific Creativity Observation Schedule. The instrument was designed in relation to the research objectives.

SCIENTIFIC CREATIVITY OBSERVATION SCHEDULE (SCOS)

The scientific creativity observation schedule (SCOS) was designed to get information about the learner behaviour, which relates to students' scientific creativity. The researcher adopted a method called Torrance Test of Creative Thinking (TTCT) to assess four aspects of creativity. A SCOS consisting of twenty items was designed by researcher to assess and guide in observing during Physics lesson. The aspect of creativity, which includes finding the scientific imagination, performing experiment, problem solving, exploration, elaboration and product development, was observed during the Physics lessons. The researcher observed the learner flexibility in reasoning, ability of the learner to plan, sensitivity of the problem and recognition of relationship between concepts during the Physics lesson. Observations were recorded after every 3 minutes interval from 3, 6, 9, 12,15,18,21, and 24 up to 39 minutes during the learning session. The tally was then calculated per sampling interval in class during learning session at least 2 times per group in order to get detailed information on the learners' symptomatic behaviour. The reason for observing after every three minutes was in order to have a pattern which facilitated recording of observation of events that was denoted on learner's creativity during the Physics lesson.

DATA ANALYSIS

Data from the scientific observation schedule was sorted, edited and corded. The descriptive analysis was done by use of frequencies, percentages, means and standard deviations. Inferential analysis was done using Analysis of Variance (ANOVA), and LSD ($\alpha = 0.05$) using the Statistical Package for Social Sciences (SPSS) Version 24 for Windows.

Hypothesis	Independent Variables	Dependent Variables	descriptive statistics	Inferential statistics
H_{01}: There is no statistical significant difference In scientific creativity in learning Physics between students exposed to IBSTA and those exposed to Conventional teaching methods in Kitui County Kenya.	IBSTA teaching Approach Conventional teaching method.	Students' scientific creativity	Frequency Mean Standard deviation percentage	ANOVA LSD

Table 1: Summary of Quantitative Data Analysis Procedure

IV. RESEARCH FINDINGS

The objective of study was to establish the difference in scientific-creativity of students taught using Inquiry-Based Science Teaching Approach and those taught using conventional methods in Physics. The research employed the Science Torrance Test of Creative Thinking (STTCT) to address the four aspects of Creativity namely: Recognition, Sensitivity, Flexibility and Planning.

AVERAGE SCIENTIFIC CREATIVITY

The information in table 2 shows the mean overall on scientific creativity after exposure to inquiry–based science teaching approach (IBSTA). The average percentage frequency for the four indicators; Recognition, Sensitivity, Flexibility and planning were computed.

Average Array	E1	C1	E2	C2
i. Recognition	61.54%	46.15%	66.15%	47.69%
ii. Sensitivity	67.69%	41.54%	69.23%	41.54%
iii. Flexibility	72.31%	47.67%	70.77%	46.15%
iv. Planning	61.54%	44.62%	60.00%	43.07%
Grand Mean	**65.77%**	**45.00%**	**66.04%**	**44.61%**

Source: The researcher, 2020

Table 2: Overall Percentage Frequency Results of Scientific Creativity after Treatment

Table 2 results indicate that the respondents from the experimental groups had better outcomes as to compare to the control groups. The average scores for the experimental groups were E1 (65.77%) and E2 (66.04%) while the average scores for the control groups were C1 (45.00%) and C2 (44.61%). The mean average arrays of experimental groups were higher than that of the control groups. These findings imply that experimental groups possessed high levels of recognition, sensitivity, flexibility, and planning than the control groups.

The respondents in the experimental group had higher levels of recognition than that of those in the control group. The study established that the inquiry-based approach had a more positive impact on learners' level of recognition. The respondents in the experimental groups were able to recall laws, principles and give their own opinions about the subject matter. In addition, the findings indicate that the respondents in the experimental groups were able to make summative analysis as compared to those in the control group who had a challenge in this aspect.

The study also established that students from the experimental groups were more sensitive in identifying of errors in apparatus, criticizing, and could give suggestions on how to solve a variety of problems. Innovation was high, and their practicality on how to discuss various topics increased. They increased their memory capacity, which in turn lead to good learning outcome.

It was also found that the experimental groups had higher levels of flexibility as an indicator of scientific creativity. They were able to better explain the topic taught from different angles, have in-depth and comprehensive understanding of the taught content, and freely asked for help from their fellow students that was not the case with students from the control groups.

The study revealed that the experimental groups planned their activities before kick starting an experiment. They setup their apparatus properly, followed procedures, carefully noted down their findings and compared their findings with the expected results from the experiments. The study also established that due to lack of knowledge, students from the control groups were very confused on how to conduct experiments. They kept on following what others did.

To understand whether there was a statistically significant difference in scientific creativity and the method of teaching approach used, the following hypothesis was tested:

H_{01}: There is no statistically significant difference in scientific-creativity in learning Physics between students exposed to Inquiry-Based Science Teaching Approach and those exposed to conventional methods.

Analysis of variance (ANOVA) was used to test the hypothesis. Table 3 presents the findings on the ANOVA computation of the significant differences between means of the four indicators of scientific creativity.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2.117[a]	4	6.147	3.114	0.001	0.87
Intercept	315.000	1	315.000	300.444	0.000	0.862
Sub Category	2.117	3	6.147	3.114	0.001	0.87
Error	33.231	48	.692			
Total	350.000	56				
Corrected Total	35.000	55				

a. R Squared = .87 (Adjusted R Squared = .019)

Source: The Researcher, 2020

Table 3: Overall Results of Analysis of variance (ANOVA) for Scientific Creativity after Treatment

The results in table 3 show that, the f-statistic was 3.114, for 3 degree of freedom and a mean difference of 6.147. This yielded a significance level of 0.001 that was less that the set value of α=0.05. This indicated that differences between the mean values were statistically significant. Mumba (2010), who reported that the use of inquiry based learning builds learner's creativity, motivates and makes them have confidence in learning science, supports these findings.

To understand further the statistically significant difference between the scores obtained, LSD was computed and the findings obtained were shown in the table 55.

(I) Sub category	(J) Sub category	Mean Dif. (I-J)	Std. Error	Sig.	95% Conf. Interval Lower Bound	Upper Bound
C1	C2	.42	.326	**.988**	1.02	1.44
	E1	6.11*	4.352	**.000**	6.22	12.33
	E2	7.55*	5.558	**.001**	7.22	14.77
C2	C1	.42	.326	**.988**	1.02	1.44
	E1	5.69*	2.335	**.005**	4.56	11.14
	E2	7.11*	3.578	**.000**	5.89	13.00
E1	C1	6.11*	4.352	**.000**	6.22	12.33
	C2	5.69*	2.335	**.005**	4.56	11.14

	E2	1.01	1.888	**.907**	3.02	4.03
E2	C1	7.55*	5.558	**.001**	7.22	14.77
	C2	7.11*	3.578	**.000**	5.89	13.00
	E1	1.01	1.888	**.907**	3.02	4.03

Based on observed means.
The error term is Mean Square (Error) = .692.

Source: The Researcher, 2020

Table 2: LSD Overall Results of Scientific Creativity after Treatment

The results in table 4, show that the mean difference between C1 and C2 (p=0.988) and E1 and E2 (p=0.907) was not statistically significant since P> 0.05. This implies that E1 and E2 groups, C1, and C2 performed relatively the same on scientific creativity. However, the comparison between the mean difference in the groups C1 and E1 (p=0.000), C1 and E2 (p=0.001), C2 and E1 (p=0.005) and C2 and E2 (p=0.000), were statistically significant since P<0.05. This shows that the experimental groups' mean score was higher than the control groups' mean score in scientific creativity implying that the experimental groups' mean score was higher than that of the control groups in scientific creativity. These findings are in agreement with a report by Ssempala (2017), who argued that teaching using inquiry based learning enhanced creativity among the learners. In addition Dawson, (2006) argued that inquiry teaching gives a learner a positive drive to be scientifically creative, imaginative and have the spirit of readiness to know more

Therefore, the null hypothesis one, that reads *H_{01}: There is no statistically significant difference in Scientific-Creativity in learning Physics between students exposed to Inquiry-Based Science Teaching Approach and those exposed to conventional methods* was rejected.

V. CONCLUSION AND RECOMMENDATIONS

SUMMARY

The respondents in the experimental group had higher levels of recognition than that of those in the control group. The respondents in the experimental groups were able to recall laws, principles and give their own opinions about the subject matter. In addition, the findings indicate that the respondents in the experimental groups were able to make summative analysis as compared to those in the control group who had a challenge in this aspect. The study also established that students from the experimental groups were more sensitive in identifying of errors in apparatus, criticizing, and could give suggestions on how to solve a variety of problems. It was also found that the experimental groups had higher levels of flexibility. They were able to explain in a better way the topic taught from different angles, have in-depth and comprehensive understanding of the taught content. The study revealed that the experimental groups planned their activities before kick starting an experiment. They setup their apparatus properly, followed procedures, carefully noted down their findings and compared their findings with the expected results from the experiments.

CONCLUSIONS

The following conclusions were made based on the summary of the findings:

- ✓ The Inquiry based science teaching approach enhances scientific creativity thus it is a good method for teaching Physics.
- ✓ Given the positive impact of inquiry based science teaching approach on the four aspects of scientific creativity (recognition, sensitivity, flexibility and planning), emphasis should be placed on inquiry based science teaching approach in teacher training institution.
- ✓ There is need to find a ways of promoting inquiry based science teaching approach through ICT given three factors.
  - The impact of covid-19 pandemic
  - The need to adopt a new pedagogy
  - To realign the teaching of physics with the new competence-based curriculum (CBC)

RECOMMENDATIONS

- ✓ Physics Teachers should adopt IBSTA since the inquiry-based approach is an interactive model that ensures students get hooked onto the session and focuses on engaging students during the learning process. It also enhances scientific creativity, among learners and consequently leads to better scores in Physics.
- ✓ School administrators should reward Physics teachers who use IBSTA to create a culture that would improve students' inquiry skills of engagement, elaboration, exploration, explaining and evaluation which consequently improves students' learning outcomes by making them creative, motivated and competent.
- ✓ A programme should be developed for the Induction and Mentorship of Physics Teachers on the implementation of IBSTA so as to empower them with inquiry skills
- ✓ Sources of funding should be identified to purchase more science practical equipment and build better infrastructure to promote the use of IBSTA by Science teachers in preparation for the implementation of the Competence-Based Curriculum.
- ✓ An appropriate policy should be developed for diploma colleges and universities to train their teacher trainees with an emphasis on IBSTA as part of their Physics training curriculum. The teacher trainees should then be assessed on the appropriate use of this method during microteaching and teaching practice in order to equip them with IBSTA skills.

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