

## The Effects of Inquiry-Based Science Teaching Approach on Task Competence of Secondary School Physics Students in Kitui County, Kenya

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### Abstract

The purpose of this study was to investigate the effect of Inquiry-Based Science Teaching Approach on learners' task competence of secondary school physics students in Kitui County, Kenya. 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 of the study was 1600 form four Physics students from 40 Extra-County secondary schools in Kitui County. Stratified random sampling was used to select four Extra-County schools (2 Girls and 2 Boys). Purposive sampling was used to select 40 students from each of the four schools and a Physics teacher from each of the two sampled schools; giving a sample size of 160. A Physics Task Competence Test (PTCT) was the research instruments. A reliability coefficient of 0.847 was obtained. The descriptive analysis was by means of frequencies, means, standard deviation and percentages. Inferential analysis was through Analysis of Variance and the Least Significant Difference (LSD) technique at a significance level of coefficient alpha  $\alpha=0.05$ . The findings showed a statistically significant difference in task competence between students taught using IBSTA and those taught by the conventional methods. The study established that Students from the experimental groups outperformed the ones from the control group in the results obtained. This showed that IBSTA had a positive effect on their task competence. There was a significant difference in the post-test (PCBT) on task competence mean scores between students in the experimental groups who were taught Physics using IBSTA than those in the control groups taught by conventional methods. Consequently, the study concludes that IBSTA is effective in enhancing students' task competence. Finally, the study makes recommendations key among them the creation of an enabling environment for IBSTA adoption in schools.

**Key words:** *Achievement, Inquiry-Based Science, Teaching Approach, Learning outcome, Self-concept and Task competence.*

### INTRODUCTION

#### Background to the Study

Inquiry-Based Science Approach teaches concepts, facts or skills that lead learners to formulate their own questions or problem thereby enhancing outcome (Bulbul, 2012). Inquiry-Based Teaching Approach is positively associated with outcomes when it incorporates teacher guidance, and negatively when it does not (Aditomo & Klieme, 2019). In another study conducted in South Africa by Baloyi (2015) on the effect of Inquiry Based Science method in teaching practical in Physics, learners developed better understanding of science concepts when using this method than the use of traditional methods. According to Chelangat (2014) in his study on effects of practical on investigation and scientific creativity amongst secondary school

Biology students in Kericho sub-County, Kenya, indicated that the use of practical laboratory investigation approach and integrating it with Inquiry-Based Approach enhances creativity amongst secondary school Biology students. Njoroge, Changeiywo & Ndirangu (2014) observed that students taught using Inquiry-Based Teaching Approach in Physics outshined students taught using the traditional method. This aspect suggests that the general poor performance in physics in Kitui County may benefit from a change of teaching methodology. However, Njoroge et.al did not show evidence that they investigated aspects of: task competence.

### **Statement of the Problem**

Persistent poor performance in KCSE Physics at both the Nationally and Kitui County in particular has been greatly attributed to factors such as Conventional instructional method, inadequate facilities, poor mastery of teaching and learning content on the part of the teacher, lack of interactive forums for learners and shortage of teachers among others (KNEC reports: 2014 to 2019). Several initiatives have been put in place to improve performance in this subject. The Government of Kenya in collaboration with Japanese Government introduced the Strengthening of Mathematics and Science Education (SMASSE) in Secondary Schools. This programme may have put more emphasis on hands-on rather than mind-on approach. Despite such effort, the performance of learners in K.C.S.E Physics continues to decline. The impact of this trend on task competence among students has been inadequately investigated. If there will be no attempt to solve the problem this worrying trend will continue. There is currently limited information on the effects of IBSTA in physics especially in Kitui County. In an attempt to bridge, this gap the current study investigated the effects of Inquiry-Based Science Teaching Approach on task competence of secondary school physics' students in Kitui County, Kenya.

### **Objective of the Study**

The objective of the study was to determine the difference in task competence between students taught by Inquiry-Based Science Teaching Approach and those taught using conventional methods.

### **Research Hypotheses**

The hypothesis was tested at  $\alpha= 0.05$  level of significance.

H<sub>01</sub>: There is no statistically significant difference in task competence to learning Physics between students exposed to Inquiry-Based Science Teaching Approach and those exposed to conventional methods.

## **LITERATURE REVIEW**

### **Theoretical Framework**

Dewey's (1938) Constructivism Theory guided this study. The constructivism theory of learning upholds that knowledge is actively constructed by organizing subjects not passively received from the environment (Lerman, 2012). Piaget and Bruner who viewed constructivism in slightly different approaches adopted Vygotsky's Theory of Constructivism. Piaget based his examples on philosophy and epistemology while Bruner focused on cognitive structure, which he called mental schema (Culata, 2019). A person's education is an element of related involvements,

mental structures, and convictions that are utilized to translate articles and occasions (Bredo, 2014). In constructivist, learning, repeated manipulation of objects and ideas enables learners to construct meaningful concepts that can be transferred to logical abstract reasoning in a formalized manner.

The rationale for using this theory is that, student learning using inquiry were based on the fact that the 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 thus will motivate the learner.

### **Empirical Literature**

A study carried out in Mexico by Llewellyn (2013) indicated that Inquiry learning is a scientific process of active exploration that uses critical, logical and creative thinking skills to answer questions by teacher guidance hence learner achievement is obtained. His argument is in line with a study conducted by Ural (2016), who observed that through inquiry learning, significant improvement occurs in all aspects of student's motivation and their task competence. In a research study in USA by Bittinger (2015) on the impact of an Inquiry-Based Approach on attitude and learners task competence in a high school physics laboratory, the finding indicated that inquiry learning in a laboratory setting improves task competence and motivation.

Harrison (2014) studied how teaching in Europe adapts to a change in pedagogy as teaching shifts from a deductive to an Inquiry Approach. The finding indicated that Inquiry activities allow teachers to collect more evidence of student performance by observation during the experiment because instead of teaching the instruction, teachers could listen to conversation for misconceptions and perform formative assessment. In a research done in Turkey by Demirbag & Gunel (2014) on effect of Inquiry-Based learning on science achievement, writing and argument skills, the findings indicated that the experimental group outperformed the control group in terms of their quality of argument given and their task competence

Inquiry-Based Learning Approach is a method that arouses learners' creativity in mathematics and science and it enhances achievement for the learner. This is according to a study in Nigeria by Abayomi (2013). According to a research carried out in Uganda by Ssempala (2017) on science teachers' understanding and practice of Inquiry-Based Instructions, it was observed that some of the teachers are conversant with the use of Inquiry-Based Science Approach yet they do not use it in teaching in their stations thus performance is still poor in sciences

According to a research by Mwanda (2016), instruction by Inquiry Approach has positive influence on learners' achievement in Biology. Munene (2015) observed that the main factor that leads to poor performance in learning Physics in Gatundu secondary schools is the use of conventional learning since the approach is teacher-centered. Conventional learning has also been observed to be commonly used in teaching physics in private and public schools in Kitui County (SMASSE Kitui county Report 2014)

## 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. Quasi-experimental designs identified a comparison group that was as similar as possible to the treatment group in terms of characteristics.

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

Group	Design Group	Pre-test	Treatment	Post-test
I	Experimental	E1	O <sub>1</sub>	X O2
II	Control	C1	O <sub>3</sub>	- O4
III	Experimental	E2	-	X O5
IV	Control	C2	-	O6

### 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<sub>1</sub> & E<sub>2</sub>) each with 40 students and control group (C<sub>1</sub> & C<sub>2</sub>) with 40 students each. Purposive sampling was used to select a teacher each from two of the sampled schools. These two teachers taught only the control groups using the conventional methods.

### Research Instruments

#### *Physics Competence-Based Test (P.C.B.T.)*

Student's task competence in both experimental and control groups in the study were evaluated using the researcher created Physics competence-Based Test (P.C.B.T). Two Physics Task Competence Test: Pre-test and Post-test, were constructed and used. Pre-test was administered to the respondents in the first week of the study to assess their pre-treatment Physics academic levels. Pre-tests are administered as formative evaluations to assess students' pre-treatment Physics academic levels (Creswell, 2005).

The pre- test was test that was used to measure students' learning outcomes in learning Current Electricity II in secondary school Physics course. The Physics test was extracted from the K.C.S.E. past papers therefore they were already standard. A test consisted of twelve structured questions carrying a maximum of 30 marks. The items tested included knowledge, comprehension and application of material learnt. They were scored at different levels along the process of answering statement questions and solving physics problems relative to respondent's

ability. The marking scheme was prepared and modified to maintain the validity of the test. The researcher assisted by the Physics teachers did examination administration, supervision, marking, scoring and recording. The Researcher analyzed the marks by calculating their mean per group.

### Data Analysis

Both the pre-test and post-test Physics Competence-Based Tests (PCBT), were marked and the marks recorded for each respondent while the data from the questionnaires was sorted, edited and recorded. On qualitative data, the researcher used content analysis approach, which emphasized on thematic analysis.

**Table 2: Summary of Quantitative Data Analysis Procedure**

Hypothesis	Independent Variables	Dependent Variables	Descriptive statistics	Inferential statistics
H <sub>01</sub> : There is no statistical significant difference in task competence between students exposed to IBSTA IBSTA other exposed to conventional teaching method in Kitui County Kenya.	IBSTA teaching Approach Conventional teaching method.	Task competence	Frequency Mean Standard deviation Percentage	t-test LSD

### RESULTS AND DISCUSSION

The objective of the study sought to determine the difference in task competence between students taught by Inquiry-Based Teaching Approach and those taught using conventional methods. Before the treatment started experimental, group1 and control group1 were given a pre-test exam. The means and standard deviation obtained for the pretest exam for both groups are presented in Table 3

**Table 3: Students Mean Scores for Each Group in the Pre-test**

	Category	N	Mean	Std. Deviation	Std. Error Mean
Pre-test score	Control	38	43.34	14.28	2.3173
	Experimental	37	42.75	13.05	2.1457

**Source: Researcher, 2020**

Table 3 shows the mean scores and standard deviation for all the respondents that undertook the pre-test. E1 had a mean score of 42.33% and standard deviation of 14.28 while C1 had a mean score of 43.34% with a standard deviation of 13.05. The findings show that the mean scores for the two groups were different with the control group C1 having a higher mean score than experimental group E1.

To check whether there was a statistically significant difference between the means of control group1, experimental groups1 a t-test was computed, and the findings are shown in table 4.

**Table 4: The Independent t-test for Pre-test Mean Score of PCBT1**

	F	Sig.	T	Df	Mean Dif.	Std. Error Dif.	95%Conf. Interval of the Dif.	
							Lower	Upper
Pre-test score	.319	<b>.574</b>	.185	73	.585	3.162	-5.717	6.887
Equal var. assumed								
Equal var. not assumed			.185	72.710	.585	3.158	-5.709	6.880

(Source: The researcher, 2020)

Table 4 shows that the t-statistical value was 0.185 with 73 degrees of freedom which yielded a significance level of 0 .574 which is higher than the set value of 0.05. This means that there is no significant difference in the means of the two groups (control and experimental). The findings of this study implies that the experimental and control groups were homogenous in terms of learning outcomes at the start of the study.

### Students Learning Outcome on the Post-test

After the learning period, a post-test exam to gauge the effectiveness of each teaching method was administered to all the groups, their percentage means and standard deviations were computed, and the findings obtained are as shown in table 5.

**Table 5: Comparison of Mean Scores and Standard Deviation of Post-test in all the Groups**

Sub-category	Mean	N	Std. Deviation
C1	45.42	38	14.63
C2	43.00	39	15.06
E1	59.75	37	10.70
E2	57.95	36	11.52
<b>Total</b>	<b>52.03</b>	<b>150</b>	<b>14.80</b>

(Source: Research data, 2020)

Table 5 shows that the experimental group E1 had a mean score of 59.75% and E2 had mean score of 57.95%. Control group C1 posted a mean score of 45.42% and control group 2 obtained a mean score of 43.00%. This finding indicates that experimental group E1 and E2 posted a higher mean score as compared to the control groups C1and C2.

**Table 6: Post-test Score by Category**

Category	Mean	N	Std. Deviation
Control	44.31	70	14.776
Experimental	58.78	80	11.122
Total	52.03	150	14.804

(Source: Research data, 2020)

The figures on table 6 indicate that the average of the experimental and control groups mean scores were 58.78% and 44.31% respectively. This means that the average mean score for the control group was lower than that of experimental group. These findings are in line with a study by Banerjee (2010), who argued that Inquiry-Based lesson had a positive effect on students and posted a very high score in an achievement test as compared to a class that was taught through traditional Approach.

To understand whether there was a statistically significant difference in task competence depending on the teaching approach used, the following hypothesis was tested:

*H<sub>01</sub>: There is no statistically significant difference in task Competence to learning Physics between students exposed to Inquiry-Based Science Teaching Approach and those exposed to Conventional methods.*

A t-test was used to test this hypothesis. Table 7 presents the findings on the t-test computation of the significant differences between means.

**Table 7: Independent t-test for Post-test Examination**

		F	Sig.	T	Df	Sig. (2- tailed )	Mean Dif.	Std. Error Dif.	95% Interval Dif. Lower	Conf. of the Upper
Post test score	Equal variances assumed	4.676	.032	-6.826	148	.000	-14.473	2.120	-18.663	-10.283
	Equal variances not assumed			-6.701	127.094	.000	-14.473	2.159	-18.747	-10.199

**(Source: Research data, 2020)**

From table 7, the control group C1 and experimental group E2 had a t-statistic of 0.185 with 148 degree of freedom yielding a significance level of 0.032, which is, less than the set value of 0.05. This shows that there was significant difference in the means of the control and experimental group. The findings of this study show that the mean difference between the pre-tests and the post-test scores show that the Inquiry based science teaching approach had a great impact on the performance of students in Physics. This is in line with Osborne (2014), who argued that science teachers’ ability to practice Inquiry-Based Instruction enhances good performance.

the present study concur with a study conducted in Europe by Shafqat (2015) who argued that Inquiry based learning is more effective as compared to traditional methods of teaching, since it improves different learning domains such as knowledge, ability and task competence that improves learner’s outcome. The findings are also in line with a study carried out in Malaysia by Rakhmawan, Setiabudi & Mudza (2015) that indicated that Inquiry-Based Learning makes a student more confident and makes learning more meaningful hence increases learning outcomes.

To further understand the different significance levels that exist between the sub-categories (C1, C2, E1 & E2), Least Significant Difference was computed. The findings obtained are shown in table 8.

**Table 8: Results of LSD Post Hoc Comparison of PCBT2 Mean Score**

(I) Sub- category	(J) Sub- category	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
C1	C2	2.421	3.118	.439	-3.743	8.585
	E1	-14.335	3.0023	.000	-20.269	-8.402
	E2	-12.532	2.894	.000	-18.252	-6.812
C2	C1	-2.421	3.118	.439	-8.585	3.743
	E1	-16.756	3.138	.000	-22.958	-10.554
	E2	-14.953	3.034	.000	-20.951	-8.955
E1	C1	14.335	3.0023	.000	8.402	20.269
	C2	16.756	3.138	.000	10.554	22.958
	E2	1.803	2.914	.537	-3.957	7.564
E2	C1	12.532	2.894	.000	6.812	18.252
	C2	14.953	3.034	.000	8.955	20.951
	E1	-1.803	2.914	.537	-7.564	3.957

\*. The mean difference is significant at the 0.05 level.

(Source: Research data, 2020)

As tabulated on table 7 the difference between C1 and C2 (0.439) and E1 and E2 (0.537) was not statistically significant since  $P > 0.05$ . This implies that E1 and E2 groups, C1, and C2 performed relatively the same on Physics task competence test scores. However, the comparison between the mean difference in the groups C1 and E1 (0.000), C1 and E2 (0.000), C2 and E1 (0.000) and E2 (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 task competence. Therefore, the null hypothesis one, that read  $H_{01}$ : *There is no statistically significant difference in task Competence to learning Physics between students exposed to Inquiry-Based Science Teaching Approach and those exposed to Conventional methods*, was rejected.

These findings concurred with a research conducted by Vandewalle, (2007) who argued that Inquiry Learning when well introduced to the learner has positive impact on students' task competence in physics. This is also in line with a study by Chopra and Gupta (2011) who argued that, inquiry-based teaching approach allows students to make meaningful real-world connections in the class as they link the relevance between what they learn in the classroom and their potential careers. Awafala (2013) observed that those teachers who use the Inquiry Based Teaching posted a high achievement (mean scores) in their subjects.

## CONCLUSIONS AND RECOMMENDATIONS

In this study the findings show that the post-test scores for students in the Experimental groups E1 and E2 ( $M_1=59.76$ ,  $M_2=57.95$ ) were higher than those in the control groups C<sub>1</sub> and C<sub>2</sub> ( $M_1=45.42$ ,  $M_2=43.00$ ). This indicates that Students from the experimental groups outperformed the ones from the control group in the results obtained. The answers and flow of calculation for the experimental group was well detailed and clearly elaborated. This showed that IBSTA had a positive effect on their task competence. The inquiry approach also enabled students to develop process skills and thus enhanced good performance.



There was a significant difference in the post-test (PCBT) on task competence mean scores between students in the experimental groups who were taught Physics using IBSTA and those in the control groups taught by conventional methods ( $F_{4.676}$ ,  $df=148$ ,  $P=0.000$ ) since  $P < 0.05$ .

The results of the study also indicated that the difference between C1 and C2 (0.439) and E1 and E2 (0.537) was not statistically significant since  $P > 0.05$ . This implies that E1 and E2 groups, C1, and C2 performed relatively the same on Physics task competence test scores. The comparison between the mean difference in the groups C1 and E1 (0.000), C1 and E2 (0.000), C2 and E1 (0.000) and C2 and E2 (0.000) were statistically significant since  $P < 0.05$ . Therefore, the null hypothesis, one was rejected.

### **Conclusions**

From the summary of the findings above, the following conclusions were made:

- a) The Inquiry based science teaching approach is a good method for teaching Physics as it enhances task competence.
- b) There is need for an environment in which inquiry based science teaching approach can be adopted in schools.
- c) 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 and to realign the teaching of physics with the new competence-based curriculum (CBC).

### **Recommendations**

Based on the study findings, the following suggestions are made: 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 competent and build; sources of funding should be identified to purchase more science practical equipment and build more infrastructures to promote the use of IBSTA by Science teachers in preparation for the implementation of the Competence-Based Curriculum; Since online practical can be carried out in science subjects, the school management should expand ICT infrastructure, computer hardware and practical integrating software for schools to conduct experiments online using the IBSTA; and 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 micro-teaching and teaching practice in order to equip them with IBSTA skills.

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