

Effects of Inquiry Based Practical Instruction Approach on students' academic performance in secondary school Chemistry in Tharaka-Nithi County, Kenya

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Abstract- Inquiry based practical is meant to promote meaningful learning in science subjects. The purpose of this study was to investigate the effects of inquiry-based chemistry practical instruction approach on the students' academic performance in Secondary Schools in Tharaka-Nithi County. The study adopted a quasi-experimental design based on pre-test and post- test arrangement. The data that was generated was analyzed using both descriptive and inferential statistics. The differences between the means of the two groups were analyzed using t-test. The statistical significance was tested at $\alpha = 0.05$. The findings of the study indicated that the students who were instructed through IBCP attained higher scores than their counterparts who instructed through CPW. In conclusion, the use of inquiry-based approach by teachers of chemistry enhanced the academic performance of students. Thus, the study recommends that curriculum developers in secondary schools should emphasize teaching through inquiry-based approach.

Key words: Academic Performance, Inquiry Based Practical Instruction Approach, Conventional Teaching Approach

1 INTRODUCTION

Inquiry based instruction approach to teaching and learning emphasises the active role of students in the learning process as opposed to a situation where the teacher tells or explains to the students what they need to know. The method encourages and promotes exploration, asking questions and sharing of ideas. Other essential feature of inquiry-based method of teaching include; collection of data to develop and evaluate their explanations. Alexander (2001) observes that inquiry based teaching methods are designed to promote active participation in the learning process. It develops among the learners high order thinking skills. Haury (1993) after reviewing literature on inquiry instruction concludes that hands on inquiry can result to scientific literacy, familiarity with scientific processes, conceptual understanding and Critical thinking. Teachers in inquiry classrooms constantly challenge and encourage students to learn using their own knowledge of science. In conventional approach of teaching learners passively, listen to the teacher with very little activities where they take part. Njoroge, Changeiywo and Ndiragu (2014) observes that students taught using inquiry-based outshines those learners taught using Conventional method. These aspects suggest that the general performance in KCSE Chemistry in Tharaka-Nithi may benefit from a shift in Methodology.

2 STATEMENT OF THE PROBLEM

The poor performance in KCSE chemistry especially in the recent years has resulted in grades that reflect below average for a number of students at school level. The available statistics indicate that poor performance in the subject has resulted to low enrolment numbers in science and other related courses in higher institutions of learning, for instance in the universities. The persistent performance in chemistry of learners, which is below average, could be as a result of many factors. Key among these factors could be the instructional approach used by teachers and resources. The Government of Kenya has attempted to reverse this worrying and disturbing trend by putting in place a number of interventions. One of these interventions mainly targets students, teachers of chemistry and the general instructional environment. Although some work has been done to reverse the trend, the performance in chemistry in Tharaka-Nithi County is still low compared to the National performance. The poor performance in chemistry may be due to inadequate exposure of students to chemistry practicals. The quality of the chemistry practicals and the frequency of the practicals could also be the other aspects of the practicals that may be contributing to this negative trend, given that practicals reinforce theory. However, of greater significance is that the exact aspect of the chemistry practicals that is responsible for the poor performance is not clear. There is minimal, if any, empirical data on the contributions of inquiry based chemistry practical instructional approach on the academic performance of students in chemistry in Tharaka-Nithi County. Therefore, this study was carried out with the hope that it may address this concern, which may make a difference.

3 OBJECTIVE OF THE STUDY.

The objective of this study was to establish the difference in performance by students' taught using integration of Inquiry Based Instruction in chemistry practicals and those taught using conventional method.

4 RESEARCH HYPOTHESES

The study was guided by the following null hypothesis, which was tested at alpha level of 0.05.

H₀₁: *There is no statistically significant difference in performance of students' who are taught using integration of inquiry-based instruction and those who are not.*

5. LITERATURE REVIEW

In the USA, a study was conducted by Bittinger (2015) that focused on the impact of inquiry –based approach on attitude and learners task competence in a high school physics laboratory. The study findings from this study reveals that laboratory setting improves task competence and motivation

In Europe, a study was done by Harrison (2014) that focused on how the region adapts to a change in pedagogy as teaching shifts from a deductive to an inquiry approach. The findings revealed that inquiry activities allow the instructors to collect data on how the students' perform through observation during the experiment. This is because the teachers had an opportunity to listen to the conversations and correct any misconceptions during the formative assessment.

In a study conducted in Mexico by Llewellyn (2013) demonstrates that inquiry learning is a scientific process of active exploration that uses critical logical and creative thinking skills by the guidance of the teacher hence achievement is obtained. This argument is in tandem with a study done in Asia by Abdi (2014) which focused on the effects of inquiry based learning method on learner's attainment in science courses. The study shows that learners taught using IBCP attains higher scores.

In Nigeria, inquiry laboratory experiments encourages and promotes learner centered method of learning. This is according to a study done by Zainabu (2017). According to a research carried in Uganda by Ssempala (2017) that focused on teacher's understanding and practice of inquiry based instruction. It was noted that teachers are conversant with IBCP yet they do not use it in their stations and this explains the performance is still poor.

A study was carried out in Kenya by Mwangi (2016) that focused on the effects of chemistry, practicals on the students' academic achievement in Nairobi and Machakos Counties. The study demonstrated that students taught using chemistry practicals recorded a higher academic achievement than their counterpart who were instructed through conventional approach. Although, this study focused on the role of chemistry practicals, it did not focus on the role of inquiry-based approach. The study is in agreement with the views of a study conducted in Nyeri County, Kenya by Njoroge, Ndiragu and Changeiywo (2014) who observed that students taught through inquiry based approach attains higher scores than those taught through Conventional method. The study was conducted in physics.

6 THEORETICAL FRAMEWORK

This study was guided by the constructivist theory whose proponent is Jerome Brunner in 1966. According to this theory; learning is an active process rather than a passive one. The learning process gives learners an opportunity to build or construct their own first-hand ideas based on either their previous or present experiences.

The theory underscores the fact that learning process should comprise of learners who actively get involved in the instruction process, instead of being inactive recipient of knowledge, as is the case with expository method of teaching and learning. According to constructivism, the should not only be actively involved in hands on but also minds on learning activities (Bruner, 1966). However, the theory has some limitations. One of the limitations of this theory is that not all scientific concepts that require to be constructed from experiences. Some concepts require direct instruction. Another limitation is that the theory assumes that learners will all the time correctly relate new knowledge to experiences. There are times when the learners are unable to do so and therefore leads to misunderstanding of newly encountered content all together.

The justification for the use of this theory in this study is that it underscores the critical role of the learner as a central component in teaching and learning process. Those learners hardly learn where the teacher gives learners information. Learning is an active process. The teachers should only facilitate the learning process. The practical activities in chemistry subject largely involve handling of apparatus, which assist the learner to collect the data through observations. For this reason, the learner must play an active role. This is what constructivist theory advocates for.

7. RESEARCH METHODOLOGY

Research design

Kumar (2005) observes that research design consist of the plan, structure and strategy of investigating questions or problems to find answers. A research design is a blueprint, which is used to collect, measure, and analyze data Kothari (2004). This research study employed a quasi-experimental approach that involved the pre-test and post-test design. The justification for the choice of this study design was, the scores of students who were exposed to chemistry practicals (experimental group) were compared to those students who were taught conventionally (control group). When using the quasi-experimental design, the study should be carried out without affecting the set-up of the classroom and therefore the learners were not aware whether they are involved in the study (Mwangi, 2016). The four secondary schools were assigned to the experimental, control group by simple random sampling technique. One girls' secondary school and one boys' secondary school were randomly assigned to the experimental and control groups respectively. The research model is represented in Table 1

Table 1: Research Design

Group	Pre-test	Treatment	Post-test
Experimental group	O ₁	X	O ₃
Control group	O ₂		O ₄

Key; O₁ and O₂ is pre-test
X is the treatment intervention (inquiry based chemistry practicals)

No treatment or intervention (conventional or usual way of practicals)
O₃ and O₄ is the Post-test

8. SAMPLING TECHNIQUE AND SAMPLE SIZE

Sampling was done purposively to choose the study samples. Orodho (2017) defines purposive sampling as a type of sampling where the researcher makes a judgement in choosing the units that represent the whole population based on his or her expertise. The units of sampling in the study were secondary schools as opposed to individual students; this is because schools operate as intact groups (Randolph, 2008). When using quasi-experimental design, the researcher should ensure that the schools sampled for the study should have almost the same mean in KCSE in chemistry for the last three years. This ensures that the schools have the same entry behavior in terms of performance and infrastructure.

With the above sampling process in mind, the researcher randomly sampled four secondary schools whose performance in chemistry in KCSE is comparable. Another important aspect that was considered in the sampling process was that the schools that were well equipped with chemistry laboratories and qualified chemistry teachers. The aim of this was to ensure that all the four schools taking part in the study had almost the same level of resources. Again, the researcher employed simple random sampling to choose two extra county boys' secondary schools and two extra county girls' secondary schools for each group. Most of the schools in the County have more than three streams. For this reason, the selection of one stream to take part in the study was done through simple random sampling. The teachers of chemistry who were involved in the study were also purposively sampled. The justification for using this method of sampling was to ensure that those selected teachers actually taught the classes that participated in the study. Secondly, they were also qualified chemistry teachers.

9. SAMPLE SIZE

A minimum of 30 learners per class are recommended for experimental group asserts Mugenda and Mugenda (2003). In Kenya, the recommended number of students per class should be 40. Four classes (intact classes) of form three students from three secondary schools made the study sample groups. The sample size comprised of four secondary schools. This included two male and two female secondary schools. Four teachers of chemistry were also selected purposively from the four schools that were participated in the study. This was to ensure that they actually taught chemistry in the classes that participated in the study.

Table 2 : Sampling Frame (Actual Populations)

School type	Categories	Experimental Group	Control Group	Chemistry Teachers
Boys School	School A	54		1
	School B		45	1
Girls School	School A	41		1
	School B		45	1
Total		95	90	4

Source: The researcher, 2022

10. RESEARCH INSTRUMENTS

In this study, three research instruments were utilized to collect the required data. The interview guide schedules for chemistry teachers and the observation checklist. The other research instrument that was utilized was the Chemistry Achievement Tests (CAT), which was offered through the arrangement of a pre-test and post-test.

11. CHEMISTRY ACHIEVEMENT TESTS (CAT)

This instrument was utilized in determining the scores of learners in chemistry practicals. The researcher constructed the Chemistry Achievement Test (CAT). The content of the test took into consideration all the levels of Benjamin Bloom's taxonomy. In order to achieve this, the researcher employed the use table of specification. (Anderson, 2001). The constructed CAT was used to evaluate to evaluate learners in the experimental and control groups in the research study. Two CATs were constructed that is the pre-test and post-test. The pre-test was from the topic "Salts" to test the basics of salts which was covered in form two chemistry. The post-test focused on Qualitative analysis.

(a) Pre-Test – (CAT)

The administration of the pre-test to the learners in the selected schools was done at the beginning of the study. This was used to check on the students' level of achievement in chemistry before being exposed to the treatment. According to Creswell (2005), pre-tests are usually given as formative evaluation to find out the pre-treatment academic levels of the students. The pre-test was used to check whether the entry behaviour of the learners was comparative in chemistry. This instrument was constructed from the topics that had already been covered previously by the learners who were involved in the study. This test consisted of 13 short questions and took one hour. To ensure validity, senior KNEC examiners checked the items. They were further counter-checked by one of the supervisors from the Department of Educational Communication and Technology, Kenyatta University who is a specialist in chemistry.

(b) Post –Test-CAT

The instrument was developed by the researcher and cross-checked by the four instructors who were participants in the study. The instrument had two questions that were generally intended to measure manipulative and process skills in inquiry based chemistry practical. The two sets of questions mainly focused on qualitative analysis that deals with the identification of cations and anions and functional groups using the commonly used chemistry laboratory reagents. Each question had a maximum of ten marks, giving the instrument 20marks. The post-test was done after teaching the learners for a duration of six weeks. At this time, most schools that were involved in the study had covered a substantive amount of work involving qualitative analysis.

12. DATA ANALYSIS

Both the pre-test and post-test Chemistry Assessment Test (CAT) were marked, the marks recorded for each learner. On the other hand, the qualitative data was analyzed emphasized on thematic analysis.

The study generated both qualitative and quantitative data. The collection of data was done using tests; Statistical Package for Social Sciences (SPSS) package version 26 was used to carry out the data analysis. Both descriptive and inferential statistics were employed analyzing the data. Descriptive analysis involved the use of means and standard deviation. The use of t-test formed the inferential statistics. It is imperative to note that inferential statistics in this research study was used to test any significant differences in the groups. On the other hand, means and standard deviation were used to describe the data. A t-test was done to establish the differences in the mean between the male and female students. The independent t-test has a superior quality in detecting differences between two means (Coolican, 1994).For this reason, it was used to test the differences between the means.

Table 3: A summary of Data Analysis procedure

Hypotheses	Independent Variable	Dependent Variable	Statistical Test
H₀₁ There is no statistically significant difference in performance of students' who are taught using integration of inquiry based chemistry practical and those who are not.	Inquiry Based Practical (IBP)	Post-test scores mean on CAT	t-test

13 RESEARCH FINDINGS

The objective of the study sought to determine the difference in academic performance between students taught through inquiry based practical approach and those taught using the conventional approach. Before being exposed to the intervention both the experimental and control groups were given the pre-test on the topic the "Salts". The scores and standard deviation for the CAT for both groups are presented in Table 4.

Table 4 :Pre-Test Mean Scores all Groups

Group	Count	Mean	Standard Deviation(SD)
EGA	54	61	10
EGB	41	62	9
CGA	42	59	8
CGB	45	61	8

Key: EGA-Experimental Group A, EGB-Experimental Group B, CGA-Control Group A and CGB-Control Group B

Table 4 shows the post-test mean score for EGA was 67 %, EGB was 72%, CGA was 46% and CGB was 42% with standard deviations of 10, 12, 14 and 11 respectively.

To check whether there was a significant difference between the means of experimental group A and control group A, a t-test was computed and the findings are shown in table 5.0

Table 5 :Comparison of Pre-Test Mean Scores of EGA and CGA

Group	N	Mean	T	Df	Sig. (2-tailed)
EGA	54	60.61	.848	94	.399
CGA	42	59.00			

Results in table 5 reveals that when the academic performance of experimental group and control group A schools are compared, there is no any significant difference; $t(94) = 0.848$, $p = 0.399$, $\alpha = 0.05$. Hence, H_{01} , that stated that there was no statistically significant different in performance of students who were taught using IBCP and those who were not was accepted. A t-test was done for the schools in category B. Table 5 shows the results for the comparison of mean scores of experimental and control groups for category B.

14. LEARNERS' ACADEMIC ACHIEVEMENT ON POST -TEST

After instructing the learners for a period of six weeks, a post-test CAT was administered to gauge the effectiveness of the teaching/ learning method to all the four groups. The percentage means and standard deviation were computed and the findings obtained are shown in table 6.0

Table 6 : Groups Post-Test Mean Scores and Standard Deviations

Groups	Count	Mean	Standard Deviation
EGA	54	67	10
EGB	41	72	12
CGA	42	46	14
CGB	45	42	11

Key: EGA-Experimental Group A, EGB-Experimental Group B, CGA-Control Group A and CGB-Control Group B

Table 6.0 show that the average percentage mean score of EGA was 67 % and that of EGB was 72 %.The mean score for CGA and CGB were 46 % and 42 % respectively. The findings of the study show that mean scores of Experimental groups were higher than those of Control groups. To check whether there was any statically significant difference between the means in the two groups, the following hypothesis was tested:

H₀₁: *There is no statistically significant difference in academic performance of students' who were taught using integration of Inquiry-Based Instruction and those who were not.*

A t-test was computed using the means to test the hypothesis. Table 7.0 shows the findings.

Table 7 : Comparison of Post-Test Mean Scores of Groups

GROUP	N	Mean	T	Df	Sig. (2-tailed)
EGA	54	66.57	8.284	94	.000
CGA	42	45.86			
EGB	41	71.98	12.154	84	.000
CGB	45	42.09			

Table 7 reveals that the two categories of schools had a significant difference in their post-test CAT. It was more significant for Experimental Group B (EGB) (Mean = 71.98) than Control Group B (CGB) (M = 42.09), $t(84) = 12.154$, $p > .001$, $\alpha = 0.05$. A comparison of pre-test mean scores was also made between Experimental Group B (EGB) and Control Group B (CGB), the results are presented in table 8.

Table 8 :Comparison of Pre-Test Mean Scores of EGB and CGB

Group	N	Mean	T	Df	Sig. (2-tailed)
EGB	41	61.66	.402	84	.689
CGB	45	60.91			

Source: The researcher, 2022

Table 8.0 shows the Experimental group and Control group in category B group of schools had a significant difference in the pre-test mean scores. The difference was more significant in Experimental Group B (EGB) (Mean = 61.66) than Control Group B (CGB) (Mean = 60.91) $t(84) = 0.402$, $p > 0.689$

Hence, H₀₁, that stated that there was no statistically significant difference in performance of students who were taught with integration of inquiry based Chemistry practicals and those who were not, was not adopted.

Therefore, the alternative hypothesis, H₀₁ was accepted. The study therefore, concluded that those students who were exposed to inquiry based Chemistry practicals registered a higher performance than those who were taught with conventional practicals. These study findings were in agreement with the findings of an earlier study by Ali (2014) which revealed that the students who were instructed through inquiry based learning approach attained higher scores than those who were instructed through the traditional method. Similarly, the results are in tandem with the position taken by (Sharon and David, 2013) that inquiry based approaches to learning impact on students' ability to understand core concepts procedure. Also, the results are consistent with findings of (Thompson, 2006) which demonstrated that inquiry based approach instruction improves academic achievement of students. Lastly, the findings of this study validate an earlier assumption by (Hattie, 2009) that inquiry based instructional approach improves student's academic performance. The inquiry-based approach produces higher academic performance compared to conventional method when instructed through lecture method (Adjei and Siaw, 2020). The assertions of this study conform with the opinion of (Rocks, 2015) who observes that inquiry-based strategy is more effective than the conventional method .The researcher notes that that the strategy is systematic because it uses thinking skills to plan, implement, evaluate and report.

The results of this study are in agreement with the views of Omokaadejo (2015) who found out that there is a significant difference on the students' performance taught through inquiry teaching method and those taught using lecture methods. Again, the findings of the study agree with (Khan & Iqbal, 2011) findings, who studied the effectiveness of inquiry based teaching approach on the development of scientific processes and skills among the ninth grade secondary schools of biology. The study findings confirm

the results of effects of inquiry-based approach on learners' academic performance in that the means attained by the students in the treatment group was significantly higher than the ones that was scored by the control group.

The findings are consistent with the assertion of (Njoroge et al, 2014) who noted that inquiry-based approach resulted to higher students' achievement in the instruction of Magnetic effect of an electric current in Secondary School physics as compared to those who were taught through regular instructional approach. Inquiry-based teaching approach remains one of the ways in which the interest of learners in learning and academic achievement can be fostered (Edeh,Nwafor,Nnaji,Fynaface and Obiekwe, 2020) This could be due to its ability to relate theory and practical thus reinforcing learner's internalisation of Chemistry knowledge.

15. CONCLUSIONS AND RECOMMENDATIONS

(a) Summary of Key Findings

The findings of the study show that the post-test scores for Experimental Group A (EGA) (67%) and Experimental Group B (EGB) (72%) were higher than the post-test scores for Control Group A (CGA) (46%) and Control Group B (CGB) (42%). This indicates that learners from the experimental groups outperformed the ones from the CGA and CGB. This showed that inquiry based approach had an impact on the attainment of academic achievement of the learners. The approach also enabled the learners to develop process skills and enhanced academic achievement among the learners.

There was a significant difference in post-test CAT between students in Experimental Groups who were instructed using IBCP and those in the control Groups who were taught by conventional method. It was more significant for Experimental Group B (EGB) (Mean = 71.98) than Control Group B (CGB) (M = 42.09), $t(84) = 12.154$, $p > .001$, $\alpha = 0.05$

(b) Conclusions

Based on the study findings above, the following conclusions were made:

- (a) The use of inquiry based chemistry practicals approach improves learners' academic achievement in chemistry
- (b) There is need to promote IBCP teaching approach so as to realign the teaching pedagogy of chemistry with the Competency Based Curriculum (CBC)

(c) Recommendations

- (i) Teachers of chemistry should be encouraged to use IBCP approach when teaching oftenly. This is because it enhances students' comprehension of scientific concepts and better their academic achievement.
- (ii) That chemistry laboratories are acritical instructional component of Inquiry Based Chemistry Practical. Therefore, Board of Management (BOM) of secondary schools should identify source of finding for not only constructing laboratories infrastructure but also ensure they are adequately equipped with relevant chemicals and reagents required to carry out IBCP.
- (iii) That Universities and Teacher training colleges should re-look at their training policies and align them with IBCP, which is a dominant and effective approach in CBC. Further, they should ensure that the teacher trainees are assessed on the use of this approach during Microteaching and the actual teaching.

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