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RELATIONSHIP BETWEEN CHEMISTRY LABORATORY WORK AND STUDENTS' ACADEMIC PERFORMANCE IN CHEMISTRY, IN KILIFI NORTH CONSTITUENCY, KENYA

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Abstract:
Despite the fact that Chemistry is the gatekeeper and backbone of other science subjects, the general performance in Chemistry among secondary school students countrywide remains poor. Research evidence shows that poor performance in Chemistry not only results from intrinsic conceptual difficulties in the subject but also springs from poor Chemistry Laboratory work. However, Chemistry educationists seem to be in disagreement with respect to the relationship between Chemistry Laboratory work and students' academic performance in Chemistry. This study, therefore, sought to find out the relationship between Chemistry Laboratory work and students' academic performance in Chemistry. The study was guided by John Dewey's Constructivist Learning theory. The study was conducted in Kilifi North Constituency. The research design was correlation, simple random sampling was used to select one girl school, six mixed schools, and Purposive sampling was used to select one boys' school. Stratified random sampling and simple random sampling were used to select 80 students. Data was collected by use of Student Questionnaire (SQ) and through analysis of documents and mark sheet form. Statistical package for social sciences (SPSS) was used to facilitate data analysis. Descriptive statistics and inferential statistics were used. The level of significant used in the study was 0.05. The findings revealed, 27.5% of schools utilize

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the expected 11-13 lessons per term, 33.75% utilizes 7-10 lessons and 38.75% utilizes 3-6 lessons. The findings emerging from this study also revealed that there was a significant positive relationship between; the use of chemistry laboratory and student's academic performance in chemistry. In conclusion, students whose teachers always take them to the laboratory during practical lessons performed better in practical examinations.

Keywords: chemistry laboratory, academic performance, Kenya

1. Introduction

This paper discusses the relationship between chemistry laboratory work and students' academic performance in chemistry, in Kilifi North constituency, Kenya. Students' performance in Kenya Certificate of Secondary Education continues to decline and thus it has raised concerns by the stakeholders. A lot of efforts has been put in place through policies and reforms in the education sector but has yielded no meaningful change in academic performance.

The objective of this paper is to determine the relationship between use of chemistry laboratory and students' academic performance in chemistry. The paper was guided by constructivist theory and conceptual frame work. Data was collected through students' questionnaires.

Section one highlights the main Objective and Rationale of the Study. Section two presents the Theoretical and Conceptual frameworks. Section three provides Methodology and Procedures. Section four and five highlights the Results of the Study and the Research Findings respectively. Section six focuses on the Conclusions. The final section presents Recommendations.

1.1 Objective of the Study

The objective was to determine the relationship between use of chemistry laboratories and students' academic performance in chemistry. It was guided by the null hypothesis: there is no relationship between use chemistry laboratory and students' academic performance in chemistry.

1.2 The Rationale for the Study

Chemistry is commonly viewed as, the "central science" as mastery of its concepts regarding the structure of matter is essential to further coursework in all sciences. Practically, everything we use has been transformed from a natural state of little or no utility to one of the very different appearances and much greater utility through a

chemical procedure. The process by which natural materials are transformed is what chemistry is all about. Arguably common items in our environment such as iron sheets, steel products, Money, ceramics, cement, fertilizer, perfumes, glass, insecticides, paints, detergents and medicine just to mention but a few, are products of chemical processes. Chemistry education is a precursor of any factors that can boost Kenya's effort toward industrialisation and thus foster economic growth and sustainable development guided by the Kenya Vision 2030. According to UNESCO (2005), there is need for Kenyan government to examine Chemistry Education alongside other science subjects to realise her vision 2030 and the Sustainable Development Goals (SDGs).

To emphasize the importance of laboratory work, Ngaruiya, Kimani and Mburu (2004) contented that through laboratory experiments chemists have discovered new materials and the chemical processes that produce them in industries. It is with this understanding that UNESCO (2005) reiterated that if school science is to be learned effectively, it must be experimented. While most people in our society recognize and appreciate the essential role of Chemistry in everyday life, it remains one of the poorly performed subjects in K.C.S.E (Ongeri, 2012).

Use of laboratory has been singled out as an important factor that determines students' academic performance in chemistry. It's evident that the teaching method applied greatly determines achievement, retention and transfer of knowledge. Hence, the need to venture into different methods used in teaching chemistry so as to choose the one that brings desired outcomes. Kenyan chemistry secondary curriculum provides for the one practical double lesson per week. This is the teaching and learning approaches that stress the importance of observation and use of data in obtaining scientific knowledge. In this method, learners are active participants in the learning process. They manipulate the learning materials and equipment.

The findings of these studies could help the curriculum developers, head of schools and teachers to re–emphasis the importance of meaningfully attending to chemistry practical.

2. Theoretical and Conceptual Framework

This study was based on John Dewey's (1896) constructivism theory. Constructivism theory was used to show relationship between the various variables. Constructivism is based on participatory learning starting from real life experience to construct knowledge. It is problem based adaptive learning strategy that challenges faulty schema, integrates new knowledge, and allows for creation of original work or innovative procedures. The focus of constructivism approach in learning is to help

learners become creative and innovative through analysis, conceptualisations, and synthesis of prior experience to create knowledge. A person's prior knowledge comes from the past experience, culture, and their environment. Generally, prior knowledge is good but sometimes misconceptions and wrong information can be a hindrance. Sometimes time must be spent correcting prior knowledge before new learning can occur.

Scientific observation has established that education is not what the teacher gives, but a natural process spontaneously carried out by the human individuals and is acquired not by listening to words but by experiences upon the environment (Woolnough & Alsop, 1985). The task of the teacher becomes that of preparing a series of motives of activities spreading over a prepared environment. Active learning conditionalises knowledge through experimental learning. The method of instruction used to learners must provide for exploration, thinking and reflection, and that interaction with the environment is necessary for learning. Constructivism does not dismiss the active role of the teacher or the value of expert's knowledge. Constructivism modifies the role so that teachers help the students to construct knowledge rather than reproduce a series of facts. The constructivist teacher provides tools such as problem solving and inquiry based learning activities with which students formulate and test their ideas, draw conclusions and inferences and pool and convey their knowledge in a collaborative environment. Constructivism transforms the students from a passive recipient of information to an active participant in the learning process. Always guided by the teacher, students construct their own knowledge actively rather than just mechanically ingesting knowledge from the teacher or the textbook. Constructivism has implication on learning and instruction. Emphasizing this Kolb (1984), proved the importance of conditioned knowledge through experiential learning. Kolb created a Model out of concrete experience, observation and reflection, the formation of abstract concepts, and testing in new situations. Kolb's beliefs are consistent with the Constructivists in that he includes Concrete Experience as part of the learning process and requires a student to test knowledge by acting upon the environment, thereby giving the student reliable, trust-worthy and conditioned knowledge The conceptual framework three independent variables but the focus of this paper is on use of chemistry laboratory, as shown in Figure 1.

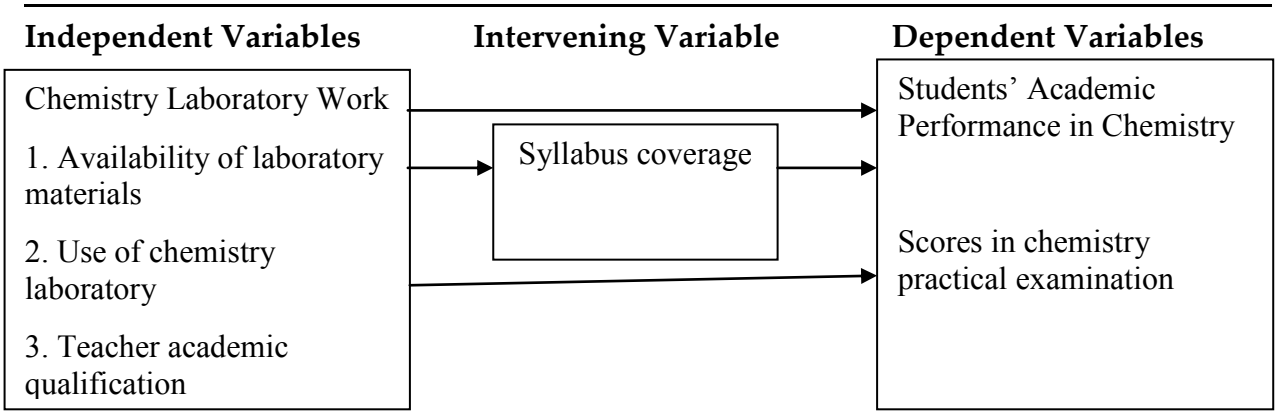

Figure 1: Conceptual Framework

3. Research Methodology

3.1 Area of Study

The study was carried out in secondary schools in Kilifi North Constituency, Kilifi County, Kenya. In Kilifi North constituency, Chemistry is offered in all schools as a compulsory science subject It was, however, observed with concern that the performance of Chemistry in K.C.S.E in the Constituency has continued to diminish This informed the choice of the County. Also the accessibility and proximity of the locale to the university.

3.2 Research Design

The study aimed at exploring the degree of correlation between two variables-the independent variable, which is the use of chemistry laboratory and dependent variable is students' academic performance in chemistry. The study employed a correlation research design to investigate the relationship between use of Chemistry laboratory and students' academic performance in Chemistry. Cohen, Manion and Morrison (2011) assert that the design involves collecting data in order to determine whether and to what degree a relationship exists between two or more quantifiable variables. Emphasizing the same, Kothari (2004) noted that correlation studies typically study a number of variables believed to be related to a major, complex variable, such as performance. The researchers were further enabled to give a report on the relationship that existed between the variables.

3.3 Variables of Study

The independent variable of this is: Use of Chemistry Laboratory. The dependent variable is: Students' Academic Performance in Chemistry. It was measured by the students' score in chemistry end of term two district mock practical examination. The

intervening variable was chemistry syllabus coverage. It was controlled through purposive sampling technique.

3.4 Sampling Technique and Sample Size

The target population comprised all public secondary schools and all Form Four students in public secondary schools in Kilifi County. The accessible population comprised 17 public secondary schools (one boy school, three girls' schools and 13 mixed schools) and 719 Form Four students in Kilifi North Constituency. Public schools were chosen for this study because of the uniformity in the curriculum offered and relatively comparable school learning environments. Form Four students were selected because they took a common mock examination that made comparison of scores possible.

Purposive sampling was used to select only schools which had completed the Chemistry syllabus by the time of data collection. Since there was Only One Boys' school in Kilifi North constituency, it was selected purposively. Simple random sampling through lottery technique was used to select one girls' school from the three schools and six mixed schools from the 13 schools. In schools with more than one stream of Form 4, simple random sampling was used to select only one stream to participate with their Chemistry teacher. Similarly, simple random sampling through lottery technique was used to select ten students each from the one boys' school and one girls' school. Stratified random sampling was used in mixed schools to select girls and Boys from the sampled classes of Form 4 to ensure sex representation.

3.5 Sample Size

The school sample comprised; One Boys' School, One Girls' School and Six Mixed Schools making a total Sample of Eight Secondary Schools out of the 17 Schools forming 47%. Eighty (80) Form Four students were sampled from a population of 719 students forming 11.13%. According to, Gatara, (2010) a 10% sample of a population is sufficient.

Table 1: Sampling Frame

	Population (N)	Sample Size	Percentage (%)
Schools	17	8	47
Students	719	80	11.13

n = 88

3.6 Research Instruments

Data was collected by use of two main instruments; questionnaires and document analysis. Student's questionnaire (SQ) was used to gather information from students on the use of chemistry laboratory in the sampled schools. The questionnaire consisted of two sections A and B. Section A contained four items on demographic information of the student. Section B contained two items on the use of Chemistry laboratory based on a Four Point Likert scale as: 1-poor, 2-fair, 3-good 4-very good. The second item on attending practical lessons was scored on a Three point Likert Scale: as 1- not at all, 2- sometimes, 3- always. Students' performance was obtained from the school records for end of term two (July-August) Chemistry Paper III (practical) examinations of 2014 Kilifi District Mock Examination and were filled in Students' Score Sheet form. A pilot study was conducted prior to the main study from two schools that were not included in the main study but had similar characteristics with the schools in the study and the schools that had taken the same mock examination. Ten (10) students were randomly selected from each of the two schools. After piloting, the researcher discovered that the time allocated for filling questionnaires was insufficient; consequently, the time assigned was increased from 30 minutes to 40 minutes. Secondly, some of the wording of the items had to be reconstructed, because it gave different and unintended meaning that was not in line with the objectives of the study. Therefore, the information gathered was vital in addressing logistical challenges like time allocated for filling the questionnaires. In addition, the information collected helped the researcher to assess if the information yielded the type of responses he anticipated and familiarize with the administration process. Pilot study also helped the researcher to check on the analyzability of the data collected as well as establishing the reliability and validity of the research instruments. The questionnaires were tested for reliability by use of test-retest method. These instruments were administered to the pilot group twice within two weeks' time interval. Obtained responses were then correlated by use of Spearman rank order (rho) as per the formula:

$$\text{rho} = 1 - \frac{\square 6\,(d)}{N\,(N^2 - 1)}$$

A correlation coefficient of 0.94 was obtained. According to Cohen, Manion and Morrison (2011) a coefficient of stability of 0.8 and above is considered to be acceptable. As such, obtained coefficient of stability of 0.94 was considered to be good enough. Face, Content and Construct validity of piloted questionnaires was ascertained by assistance of supervisors and other experts from the Pwani University School of

Education. It was also ensured through cross checking of items against the study objective. According to Mugenda and Mugenda (2003), experts can be used to validate research instruments. Random sampling of participants helped in increasing internal and external validity of the study.

3.7 Data Collection Procedure

To collect data, the researchers visited the participating schools. In all the schools, the researchers were given an appointment date to administer the questionnaires in person. The subjects were asked to respond to the questionnaires immediately after a brief introduction. The researcher filled the mark sheet form with the assistance of the head of science department filling in the scores of the student of mock practical examination. The return rate of the students was 100%. In addition, it was noted all the questionnaires were fully answered.

3.8 Data Analysis and Presentation Methods

Product Moment Correlation of Coefficient was applied to determine the relationship between the independent and dependent variables. Pearson Product Moment Correlation of Coefficient is suitable in measuring the degree of relationship between variables (Kothari, 2004). The null hypothesis was tested .05 significant level. It stated: there is no relationship between Use of Chemistry Laboratory and Students' Academic Performance in Chemistry. Percentages and frequencies were used to describe the participants, schools and use of laboratories.

4. Results and Discussion

The objective of this study was to establish the extent to which students use the chemistry laboratory; this was measured by the number of chemistry practical lessons attended by students per term. Table 1, summarizes the responses from the students on the use of laboratory, it shows that majority of students (38.75%) attended 3-6 chemistry practical lessons per term out of the total expected 13 lessons per term (assuming that an average term has 13 weeks), 33.75% of students attended 7-10 chemistry practical lessons per term and 27.5% of the students reported that they attended 11-13 chemistry practical lessons in a term.

Table 1: Use of Chemistry Laboratory

Number of Lessons Attended	Frequency	Percentage
3-6	31	38.75
7-10	27	33.75
11-13	22	27.5
Total	80	100.0

n= 80

A related question was asked to say how often they are taken students to the laboratory for practical lessons by their chemistry teachers. Results are presented in Table 2. Majority (62.5%) of teachers sometimes took students for chemistry practical lessons while few (37.5%) of teachers always took students for practical lessons.

Table 2: Teacher Taking Students for Practical Lessons

Teacher Taking Students for Practical Lessons	Frequency	Percentage
Sometimes	50	62.5
Always	30	37.5
Total	80	100.0

n = 80

The analysis of research objective called for the testing of the null hypothesis which was stated as follows: *there is no relationship between use of Chemistry laboratories and students' academic performance in chemistry.* The hypothesis was tested using Pearson Product Moment Correlation of Coefficient. Table 3, shows the correlation between use of laboratory and students' academic performance in chemistry practical. Information in the Table 3 shows that, there was a highly significant correlation ($r = 0.690$, $\alpha = 0.000$) at $\alpha = .05$. The coefficient of determination of r^2 of 0.4761 reveals that 47.61% of performance in chemistry practical is explained by use of laboratory and that, 52.39% remaining part is attributed to other variables that this study did not consider. Hence, the null hypothesis H_{02}, which stated that, there is no relationship between use of Chemistry laboratory and students' performance in Chemistry, was rejected in favor of the alternative hypothesis.

Table 3: Correlation between Use of Laboratory and Students' Academic Performance

Paired Variable	Correlation	Sig
Use of Laboratory and School Mean Score in Chemistry Practical	0.690	0.000

n=80.

5. Discussion of Results

According to Faroumbi (1998) students tend to understand and recall what they see more than what they hear, students can visualise concepts when they actually use laboratories in the teaching and learning of science. Even more Prince (2011), argues that demonstrations and practical work have immense heuristic value, tremendous rhetorical power, an overwhelming persuasive force…. He stated that, "*if you don't see it, you won't believe it. And if you don't believe it you won't understand it. And if you don't understand it, you won't long remember it*". The senses are important, not only for first discovering, but also for receiving knowledge…. Tobin (1990) emphasized that laboratory activities appeal as a way to learn with understanding and at the same time engage in a process of constructing knowledge by doing science. According to Dahar and Faize (2011), learning and the understanding level in science is improved when students are engaged in science laboratory for practical.

To emphasize the importance of laboratory work, Ngaruiya, Kimani and Mburu (2004) contented that through laboratory experiments chemists have discovered new materials and the chemical processes that produce them in industries. It is with this understanding that UNESCO (2005) reiterated that if school science is to be learned effectively, it must be experimented.

Dahar and Faize (2011) are also in agreement that learning and the understanding level in science was improved when students were engaged in science laboratory for practical experiments. Further Hofstein, Shore and Kipnis (2004), suggested that if designed properly the science laboratory has the potential to play an important role in attaining cognitive skills such as scientific thinking, inquiry skills as well as understanding the process of scientific protocols. Ostensibly, when properly developed, laboratory has the potential to enhance students' achievement, conceptual understanding and understanding of the nature of science as well as their positive attitudes and cognitive growth (Kurbanoglu, Izzet, Akim & Ahmet, 2010). In support Keys, Hand, Vaughin and Collins (1999), in their studies found that the use of science writing heuristic facilitated students to generate meaning from experimental data and make connections among procedures, evidence, and claims, and engage in meaningful learning.

Kitheka (2005) noted that schools with abundant resources like laboratory materials did not always utilise them efficiently and consequently failed to raise student's level of performance. Conversely, schools with limited resources like laboratory materials may utilise what they have efficiently and this may boost learning and consequently achieve educational objectives. In the same vein, Obwacha (2005,

October 6) describes a certain school as "*the sick man of the National schools in Kenya Certificate of Secondary Education (K.C.S.E)"* inspite of possessing adequate facilities and 74 teachers. Similarly, Munyori (2006, March 6) concluded that some National schools are a National shame. This was in reference to the poor performance of the three schools that tailed in the 2005 Kenya Certificate of Secondary Education (K.C.S.E) examination in the National school category, according to the results published in the Daily Nation and the Standard newspapers of March 2, 2006. The two scenarios exemplify of the importance of utilisation of resources especially laboratories.

The researcher discovered that most teachers do not always take students to chemistry practical lessons. Schools whose teachers always took students to practical lessons recorded higher performance in chemistry practical. While those schools whose teachers did not always take their students to practical lessons recorded low performance in chemistry. The findings of this study revealed that there was a significant relationship between use of laboratory and students' academic performance in chemistry

6. Summary of Main Findings and Contributions to Knowledge

On the basis of the findings of this study, it was revealed that most teachers do not utilize the practical lessons as expected. Majority of them only attend to less than half of the expected practical lessons. From this study, it can be clearly concluded that students' academic performance in chemistry was mostly attributed to inadequacy in laboratory use.

The role of laboratory work is truly multifaceted and thus requires examination and analysis from a variety of perspectives. A great deal of research has been conducted in the area of general laboratory work. Despite some uncertainty concerning the degree to which laboratory work affects students' academic performance in chemistry, the vast majority of literatures and experimental evidence in this area in this area has generally acknowledged significant benefit to the students' academic performance in chemistry. The results of the present study overwhelmingly confirm such perceived benefit. The largely supportive perceptions of students' participants in the present study only serve as further emphasis for such a need as well as the impetus for further research in order to clarify the scope of such a requisite.

8. Policy Recommendations

1. Given that secondary education is part of basic education Ministry of Education Science and Technology the government should ensure that educational resources like laboratories are adequate in all categories of secondary schools.
2. The government should introduce refresher courses targeting science teachers who should remain relevant in the dynamic world full of new scientific knowledge, discoveries and concepts.
3. Students should be given more opportunity to experience science by being exposed more to practical work which may enhance better performance in science subjects.

9. Recommendations for Further Research

This study, while it has achieved its purpose, has raised a number of other questions that warrant further research. Additionally, the methodology and findings of this study open up several avenues for further research and discussions:

1. Another study should be carried out in another locale for the sake of comparison of the results
2. Another study should be conducted to explore other factors that could be contributing to poor performance in Chemistry in Kilifi North Constituency, Kilifi County other than laboratory work
3. Study on the relationship between students' performance in primary science and student's performance in chemistry to determine whether students' performance in primary science affects his/her performance in Chemistry

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